The Journal of ELECTRICITY, POWER and GAS

DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

VOL. XV.—No. 3 SAN FRANCISCO, CAL., MARCH, 1905. YEARLY SUBSCRIPTION - $2 00 SINGLE COPIES - 25 CENTS

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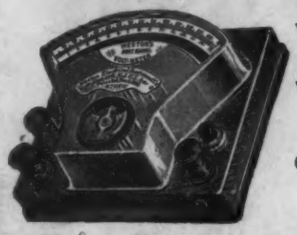

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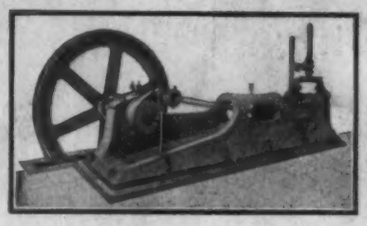

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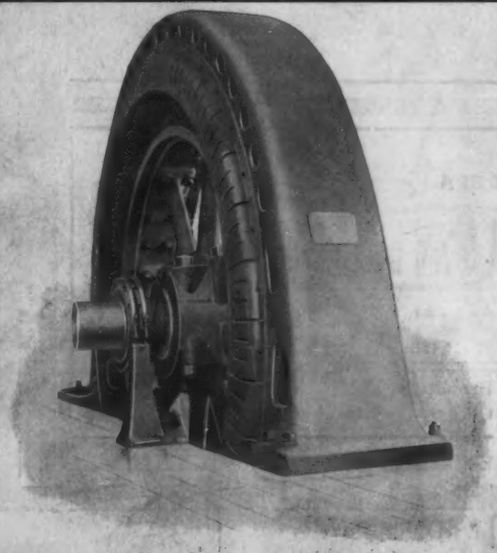

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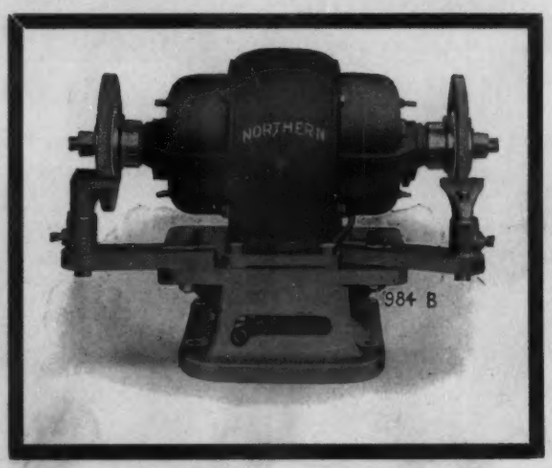

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VOLUME XV. SAN FRANCISCO, CAL., MARCH, 1905. NUMBER 3

The Old Dutch Windmill at Golden Gate Park, San Francisco.

AN unique picturesqueness which could not possibly be otherwise attained has been given to the ocean frontage of Golden Cate Park, San Francisco, through the erection thereon of a great Dutch windmill that, in being the largest wind motor in the country, possesses numerous features of engineering interest which are bound to demand more than passing notice. The problems confronting the designers of such a wind engine are far more complicated than those appearing on the surface, and these complications are mainly chargeable to the fact that the mill consists of a ponderous mechanism exposed to every vaguery of winds not only in the matter of directions but also of velocities varying from gentle breezes to gales that blow to as high as seventy miles per hour. Under the latter conditions the wind stresses become simply terrific, far more so than are necessary to wreck the mill unless every possible precaution has been taken. Great structural strength is therefore the vital requisite to successful operation, but many minor though still vital considerations appear, such as the problem regarding the regulation of the mill and the mechanical transmission of its power from the main shaft to the pumps. The methods by which success has been attained in these premises form the subject of this article.

As intimated, the Dutch windmill is distinctively a pumping engine, and as such is supplemental to the model steam station which forms the Park Water Works, So reliable has the windmill become, however, that the water system which it supplies is now entirely independent from the main water works, as will be detailed later.

THE GREAT DUTCH WINDMILL· IT'S ON THE OCEAN BOULEVARD, IN GOLDEN GATE PARK, SAN FRANCISCO

The building structure rests on a conically-shaped sub-base of concrete consisting of a mixture of one part Portland cement to eight parts of sand and finely divided rock. As a foundation there was first placed on the sand a circular dias of concrete fifty feet in diameter with a thickness of four and one-half feet, and upon this foundation there was erected the conical concrete sub-base which has an outside diameter of forty-two feet and a height of thirty feet above the upper surface of the foundation dias. This sub-base has a wall that is four feet in thickness at the bottom and tapers in gradual curva-

tures to a thickness of two feet six inches at the top. Eight circular windows, each thirty inches in diameter, give light to the pump room which it encloses. The sub-base is bound together horizontally into absolute permanency by means of heavy steel cables that were coiled into it during the laying of the concrete, as well as vertically by means of cables that extend from the main timber uprights down through the sides at eight different points into the foundation where they are securely lashed to iron rails that are embedded well into the foundation.

Across the top of the sub-base were laid two twelve by twelve-inch timbers of Oregon pine, each being of sufficient length to project over the sides of the sub-base so as to form the supports of the twelve-foot platform that in surrounding the mill marks the top of the sub-base and the bottom of the wooden tower. Upon these sills in line with the center of the top of the sub-base four twelve by twelve-inch Oregon pine timbers, each forty-eight feet ten inches long, were erected so that their bases form the corners of a square, and midway between them four Oregon pine timbers, each eight by eight inches square and of similar length, were next erected so that the outer lines of these standing timbers formed an octagonal section. These timbers were doubly strapped to their sills by means of one-inch by twelve-inch steel plates with lugs forged on to their ends and bolted together by means of three-quarter-inch bolts, the lugs on the lower ends of the timbers being bolted through their respective sills by means of eight one and one-quarter-inch round steel bolts. These standing timbers were then rigidly trussed by means of six-inch by twelve-inch timbers, after which the outer surface was rounded to circular form and finally weatherboarded and shingled.

At the top of the circular wooden structure the upper end of the twelve by twelve-inch uprights is surmounted by a square frame consisting of twelve by twelve-inch timbers which are bolted to the uprights by means of eight and one-quarter-inch bolts that clamp steel plates in a manner similar to that described as prevailing at the lower ends. This frame constitutes the foundation on which is supported the revolving steel turret that carries not only the great windmill, with its shaft and gearing, but also the elliptically shaped dome which houses them. The turret has an outside diameter of twenty feet five inches and the ring constituting its base is of rolled steel I-beams fifteen inches in depth and riveted into a circle with a web diameter of nineteen feet ten and one-half inches. On the outer side of this ring is a trundle gear formed of 508 three-quarter-inch steel pins, with a pitch of one and one-half inches, and bolted to the inner periphery of the fifteen-inch I-beam circle are twenty-four cast iron chairs which carry the main turret rollers on one and one-half-inch steel shafts. These rollers have a maximum diameter of twelve and one-half inches and taper toward the center of the mill. Upon the circular cast iron beveled rail which rests upon the rollers is built a ring of three-quarter-inch by sixteen-inch steel plate, that in turn carries a wooden ring ten inches thick. It is this wooden ring that in reality forms the base of the revolving portion of the turret. Across it are laid four twelve by twelve-inch Oregon pine timbers placed parallel with each other, and which in turn support the main transverse timbers of the turret, that are also of Oregon pine, but with sections measuring sixteen inches by eighteen inches. To these main timbers are securely bolted the main journal and thrust bearings which carry the main shaft of the great mill. The turret thus revolves on both vertical and horizontal rollers to reduce friction and keep the dome central.

This main shaft, which was made in Bethlehem, Pa., of nickel steel, has an over-all length of eighteen feet nine inches; it is thirteen inches in diameter turned down to twelve inches at the main journal and gradually tapered for twenty-four inches at the lower end to a diameter of eight inches, which is again reduced in the remaining twelve inches of the length of the shaft to a diameter of six inches, which is that originally installed in the lower or thrust bearing. This thrust bearing, which was originally a step bearing, however, proved to be deficient in bearing surface, with the result that some months ago it was superceded by a new bronze bearing of the marine type, wherein a steel liner with one-inch walls was shrunk on the shaft so as to give the latter an outside bearing diameter of eight inches. As thus corrected the thrust bearing has proved satisfactory in every way.

The fact that the main shaft is placed at an angle which throws the plane of revolution of the great mill considerably out of the vertical is due to consonance with practices which have prevailed in Holland for generations. In fact the Dutch engineers determined by experiment many years ago that a material increase in efficiency resulted from such a procedure in the erection of windmills, hence the center line of the main shaft of each windmill is elevated from 10 degrees to 15 degrees above the horizontal plane, because, as implied, it is found by experience that the direction of the wind is not tangential to the earth's surface, but is from 10 degrees to 15 degrees above a tangent to the earth's surface This direction varies with localities. The principal cause of this seems to be the friction of the air on the surface of the earth. In the present instance the mean of this range was adopted, with the result that the shaft is mounted at an angle of 12 degrees and 30 minutes.

The details of the mode of mounting the great mill, together with the features of the turret and its accessory equipment in section are presented in the accompanying line drawing, from which it will be seen that a massive iron hub capping the outer and upper end of the main shaft carries the main arms of the great mill. These arms, which are four in number, consist of two center-supported sticks of specially selected Oregon pine timber, each of which has a sectional area measuring sixteen inches by twenty inches at their centers and tapering gradually towards the ends or tips, where they measure eight inches by ten inches in cross-section. The periphery described by these arms forms a circle having a diameter of 102 feet. The sails, including wind-board, are ten feet wide at the end of the arms and nine feet at the top.

Both sails and wind-board are considered as one unit, which furnishes the exposed surface for the action of the wind. Each arm has about 396 square feet of effective wind area, or a total for the four arms of about 1584 square feet. The hinged wind-board has a width of twelve inches at the top and seventeen inches at the bottom, and is hinged in order that it may be folded over

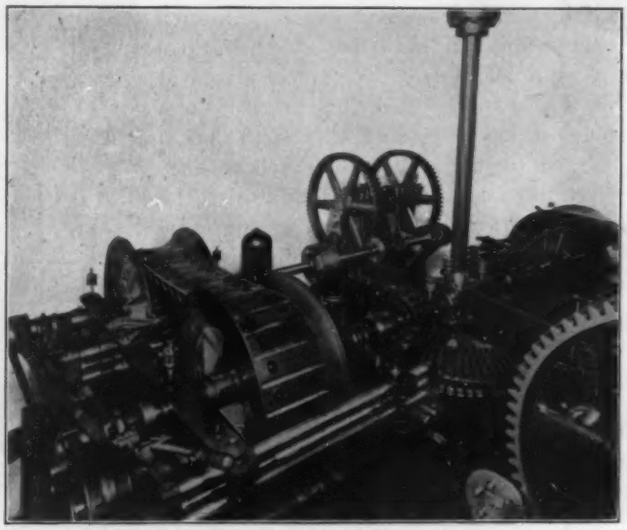
WITHIN THE DOME OF THE DUTCH WINDMILL

and bolted to the arm out of the wind in event of high wind. The canvas area may also be restricted to the extent of one-half the maximum by furling it at the center.

One of the problems encountered in designing a windmill of this character rests in deriving a solution for the means to be adopted for keeping the main wheel directly in the face of the wind regardless of any variation in the quarter whence it blows. To the layman the problem may be difficult of solution, but in reality it is very simple. To understand it, it is only necessary to draw a parallel in which the turret of the mill and all that it supports is to be regarded as a ship at sea. The latter is always under the unfailing direction of its rudder, so the turret instantly obeys the commands of the auxiliary or steering windmill with which it is equipped—obeys it in that through a system of shafts and bevel gears motion is imparted to the turret in either direction according to the direction of rotation of the steering windmill. This small wheel, which has a diameter of twelve feet, is permanently mounted in a fixed and immovable position on a scaffold forming an extension of the turret, so that the blades of the small windmill are in direct line with the main shaft of the great mill. Clearly, then, when the main windmill is facing the wind squarely, the steering windmill is, to use a nautical term, "in irons," in that its blades, being in line with the direction of the wind, derive no energy from it, and consequently the wheel stands still. If, however, the direction of the wind changes two or more points of the compass in either direction, the blades of the small wheel receive energy from the wind, and this energy is trasmitted through the set of shafts and gearing to the turret, which is moved about in proper direction so long as the small windmill continues to revolve. And when the latter ceases motion the main windmill will again be facing the wind squarely. The steering mill is geared to the trundle gear at the ratio of 4525 to 1, and so sensitive is it that a variation of two points in the direction of the wind, as stated, will influence the steering mill and through it cause the turret to be brought about as necessary.

To particularize, the motion of the steering windmill is reduced through three bevel gears, the first of which, that mounted on the shaft of the small windmill, has a diameter of thirty inches, a five-inch face, a two-inch pitch and carrying forty-seven teeth which engage with a nine-inch pinion. The larger wheel of the second gear has a diameter of twenty-five and one-half inches, a pitch of one inch and eighty teeth of a face of two and one-half inches, its shaft being one and seven-sixteenths inches in diameter. No clutch is used on this gear, but the pinion driven therefrom is clutched to its shaft. This clutch, however, is used only to disengage the gearing when the entire mill is in idleness, and in this instance the small windmill, as well as the great mill, is securely lashed to prevent motion under any direction of the wind. The driven pinion from the first gear has a diameter of five inches, with sixteen teeth of two and one-half inches face and a one-inch pitch. The third gear is of bronze, with a diameter of six and eleven-sixteenths inches, a pitch of one and one-half inches and a face of three inches carrying fourteen teeth, and on the last shaft is mounted a six-foot hand wheel for turning the turret manually.

Within the dome at a point about one-third of the distance from the lower end of the main shaft and immediately over the center vertical axis of the building is



A VIEW OF THE PUMPING SECTION OF THE DUTCH WINDMILL

keyed a gear having a diameter of six feet, along the side of which is bolted a cast iron band brake wheel. This brake wheel has a six-inch face and is supported through six steel bolts to the gear wheel. Its upper semi-periphery carries the brake proper, consisting of a band of steel surfaced with sixteen heavy blocks of oak, and

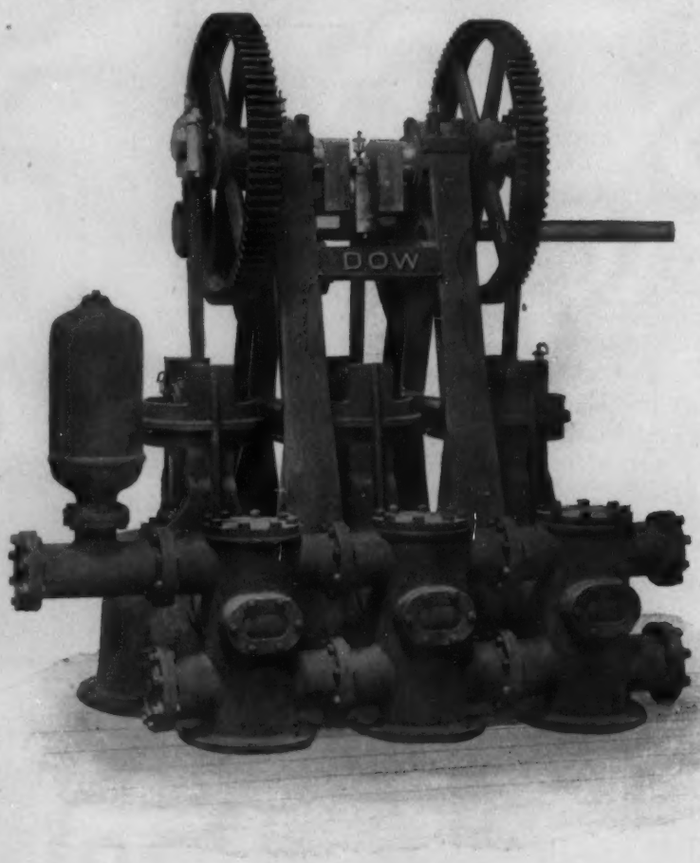
actuation is given to the brake through two levers, the lower of which carries a steel box that is seven feet long with a square area of fifteen inches to the side. This box is filled with broken iron castings, and the arrangement is such that on relieving the brake from the wheel the weight is pulled up by means of a rope that extends down through the windmill tower. At the outset confidence was felt that this brake would hold the mill from motion regardless of the position of the sails with reference to the wind; but it has been found in experience to be altogether ineffective, except that when the turret has been turned so as to throw the mill out of the wind the brake will hold it from motion due to any slight variation of the wind. In fact, if the wind strikes the sails at all fairly the brake appears to exert no material retarding influence to its motion. Under present conditions, therefore, constant vigilance must be exercised to keep the sails out of the wind during periods of idleness, and this is done by means of a hand wheel which engages the mechanism of the steering or auxiliary windmill and enables the turret to be kept manually in the position that will cause the least influence to be exerted on the mill by the wind.

As stated, the brake wheel and large gear wheel are placed side by side and bolted together on the main shaft. The driving gear has a diameter of seventy-one and five-sixteenths inches, a pitch diameter of three and one-half inches and a seven-inch face in which are sixty-four teeth, the whole being of massive cast iron. Into this driving gear meshes the pinion that surmounts the vertical shaft which decends through the structure into the pumping section. This pinion has a diameter of eighteen and fifteen-sixteenths inches, its pitch diameter is three and one-half inches and it has seventeen teeth. This gear is therefore in the ratio of 3¾ to 1. The driven pinion is placed at the top of the vertical shaft by means of a standard key-way, and this shaft has a diameter of four and one-half inches.

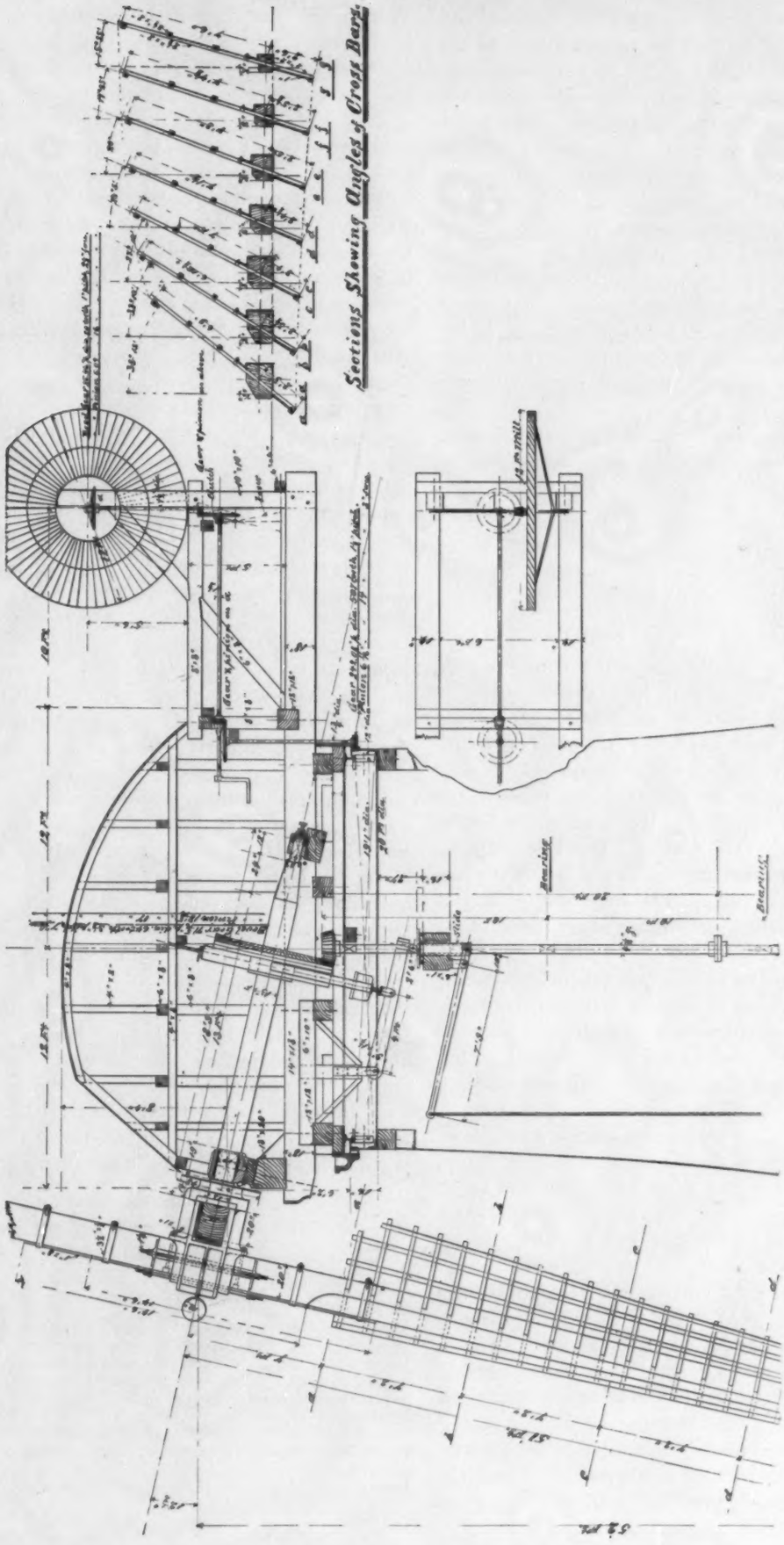
Within the structure are four stories, the floor timbers of each of which support bearings for this shaft, the lower end of which is carried in a marine type thrust bearing of bronze that consists of four collars running in oil in a bronze bearing. It is significant of the efficiency of this bearing to state that after running continuously for eighteen months the oil contained in the bearing, which amounted to five gallons, was drawn and found to be perfectly clear.

Immediately above the thrust bearing at the bottom of the vertical shaft there is keyed to the latter a bevel gearing with wooden teeth. The driving gear has a diameter of three feet and engages with two one-foot four-inch pinions, each of which drives its own pumping set through a variable speed transmission that allows of the adjustment of any desired ratio of speeds between the velocity of the windmill shaft and the speed of the pump, and in addition to this is done under conditions which permits a full range of speed variation to be effected by the hand of the windmill attendant without in any way interfering with the action or motion of the mill. The principal features of the arrangement are, therefore, first, an exceedingly quiet action accompanied by no disagreeable noise, indicating wear and tear; and second, the perfect control of any variation that may be required in the ratio of the power transmission gearing existing between the mill and the pump.

The power delivered from the vertical shaft is transmitted through a Reeves variable transmission having a maximum range of variation of 1 to 4 and thence through an eight-inch pinion to the main gear wheel of the pump shaft, which wheel has a diametar of three feet three inches. The pumping plant itself consists of two vertical single acting triplex plunger pumps built by the Geo. E. Dow Pumping Engine Company, of San Francisco, which concern erected all the machinery in the pumping section of the windmill. The plungers of these pumps each have a diameter of eight inches by a stroke of ten inches, and the equipment combines all the latest ideas in the line of geared pumps. The two main gears are keyed one to each end of the main crank shaft. A pin of liberal size is inserted in each end of the gear wheels which drive the two outer pumps of each set, and the third pump is driven by a single-throw crank placed in the middle of



ONE OF THE DOW TEN-INCH BY TEN-INCH VERTICAL TRIPLEX POWER PUMPS INSTALLED IN THE DUTCH WINDMILL



DETAILS OF THE TURRET, MAIN AND STEERING WINDMILLS OF THE GREAT DUTCH WINDMILL AT GOLDEN GATE PARK, SAN FRANCISCO

the main shaft. The three plungers are packed and guided from the outside, and so arranged that all the parts of the power attachment subject to wear are adjustable. The connecting rods have bronze boxes at the crank ends and bronze bearings at the cross-head ends, and as all gears are machine cut they operate without noise. The valve chambers are separated from the plunger chambers in a way that makes each group of suction and delivery valves both convenient and accessible. The pumping plant has a rated capacity of 40,000 gallons per hour, or approximately 1,000,000 gallons per day of twenty-four hours. This capacity, however, has never been reached in actual service, although no doubt is felt that the mill is capable of delivering sufficient power for its performance were the wind constant during twenty-four hours.

The calculated horsepower for the exposed sail area, and considering the angles at which the wind strikes the sails, are as follows:

Miles Per Hour	Horsepower
10	4.65
16	18.80
20	37.30
25	72.50
30	126.00

With a wind velocity of sixty miles per hour the sails are supposed to be all reefed, with the wind-boards turned up, and in this condition the fibre strees on the arms at the hub will not exceed 1000 pounds per square inch, which is far within the limit of safety. If the sails and wind-boards were in position, and the wind had a velocity of sixty miles per hour, the fibre stress at the hub would be rather great for safety. It is interesting to note that in any instance the velocity at which the tips of the sails travel is two and one-half times the velocity of the wind, whether the mill is working under the full load or under no load conditions.

The water lifted by the mill is not taken from wells, but instead an abundance of surface water is available, and singularly as it may appear, although this water is pumped from an excavation on the beach located within 200 yards of the surf, it is now fresh and pure, although at the outset when the mill was started, in May, 1903, it was slightly brackish. This excavation has a length of 250 feet, and although its depths are now in three stages, namely sixteen, twelve and nine feet, these are to be made uniformaly twenty feet at an early date, for at this depth quicksands will be reached and a much heavier flow of water than now occurs will be made possible. A twelve-inch cast iron pipe with foot valves constitutes the suction for both pumps, and this suction has a length over all of approximately seventy-five feet, with an average lift of twelve feet. The suction pipe is provided with a ten-inch air chamber placed near the foundation wall of the tower, this chamber being used for trapping any air that may have entered the suction either directly or by the action of the vacuum in liberating air from the water. The chamber is provided with a gauge glass which gives indication of the necessity of blowing out the entrained air, an operation that is accomplished by introducing direct pressure from the discharge pipe line into the suction when the pumps are idle.

Until well outside the mill the discharge pipe has a diameter of twelve inches, but the main pipe line is uniformaly of a diameter of ten inches, and in all its length is approximately 6000 feet. The mill supplies water for the entire westerly end of the park beyond the Chain of Lakes, and in sodoing it furnishes all water used in irrigating as well as in keeping filled the ocean reservoir, the Chain of Lakes and Spreckles Lake, more popularly termed "The Model Yacht Lake." There are two separate deliveries from the pipe line, namely, that to the reservoir and to the Chain of Lakes, the water for supplying Spreckles Lake consisting of the overflow from the reservoir. When pumping into the Chain of Lakes the gauge stands at a pressure of thirty-two pounds per square inch, and when pumping into the reservoir the gauge stands at fifty-three pounds, the increase in head due to pumping in the latter instance being approximately twenty-one pounds.

The meteorlogical conditions which prevail in San Francisco are fortunate in that the most constant winds prevail during the summer months, and in fact the records taken in Golden Gate Park show that the mill performs its heaviest pumping duties during the months of June, July and August. The accompanying table shows the duty rendered from May to January, inclusive, of the year past, the figures presented giving the minimum, maximum and average daily duty performed by months, the total duty by months, the average gallons of water lifted per hour by months, and the total number of hours per month in which the mill was in operation. A more analytical table is also given herewith showing the daily performance of the mill during the month of June, and it is instructive to note that the records of the Park Water Works for this month show that the estimated expense for windmill operation is $155.50. Taking this cost of operation, which presumably does not include interest on the original investment (almost exactly $20,000) nor depreciation or insurance, in conjunction with the duty rendered amounting to in excess of 5,205,000 gallons, places the cost of pumping for the month at $0.02987 per thousand gallons.

DAILY PUMPING DUTY.

Month 1904	Minimum	Maximum.	Average.	Total	Gallons Per Hour	Total Hours
1904						
May	22,470	189,930	79,317	2,458,846	....	.....
June.....	5,460	271,397	173,504	5,205,123	14,745	353
July.....	37,654	337,480	163,818	5,078,370	12,426	408
August ...	28,678	383,870	188,718	5,850,271	14,248	410
September	14,040	295,685	87,804	2,634,144	11.879	221
October...	12,480	145,960	23,471	727,601	10,176	71
November	12,480	207,636	46,187	1,395,628	12,578	103
December	19,565	196,417	54,362	1,685,229	13,414	126
1905						
January ..	16,575	297,167	49,342	1,529.620	13,617	112

PUMPING DUTY FOR JUNE, 1904.

Day of Month	Gallons	Day of Month	Gallons	Day of Month	Gallons
1	75,348	11	No wind	21	179,829
2	269,171	12	5,460	22	207,207
3	179,400	13	163,254	23	135,557
4	62,686	14	269,558	24	142,470
5	110,123	15	280,280	25	119,691
6	371,397	16	218,491	26	40,716
7	128,167	17	271,557	27	260,000
8	70,512	18	187,200	28	260,910
9	363,311	19	146,250	29	101,400
10	91,728	20	330,720	30	162,760
Total..	.....	.....	.....	.....	5,205,153

Cost of pumping 1000 gallons of water at an estimated monthly expense of $155.50 equals $0.02987 per thousand gallons.

The wind mill proper was designed by J. C. H. Stut, mechanical engineer, while the mechanical engineering features pertaining to the power transmission and pumping system were designed conjointly by Geo. E. Dow, president of the Geo. E. Dow Pumping Engine Company, San Francisco, and H. D. Seville, then superintendent of the Golden Gate Park Water Works, and now chief engineer of the Merchants' Exchange Building, San Francisco. The concrete and carpenter work was erected by John Dougherty, of Golden Gate Park, all being installed under the direct engineering supervision of Mr. Seville. The mill is now operated under the direction of C. M. Irwin who succeeded Mr. Seville to the superintendency of the Park Water Works.

In conclusion it should be stated that the inception of the installation of the great windmill at Golden Gate Park is to be accredited to Irving M. Scott, then a Park Commissioner, to whom it occurred while making a trip to Europe some years ago that a structure of this character would materially enhance the landscape beauty of the ocean frontage to the Park. The idea was suggested to John McLaren, superintendent of the Park, who in promptly accepting it became an enthusiast in its favor. Much opposition was encountered in carrying out the project. In its accomplishment, however, Mr. McLaren has attained an unique result, for it is a rule to which an exception is scarcely to be hoped for that investments made in public recreation grounds of the nature of Golden Gate Park will not be remunerative beyond the thanks of an appreciative public. In the present instance, however, thanks to Mr. McLaren's devotion to the public good, he has in securing the erection of the windmill not only added a delightful picturesqueness to the ocean boulevard, but he has made the investment a productive one in every financial sense.

BREAKDOWNS CLASSIFIED.

The break down of electrical machinery has been investigated by the Engine, Boiler and Employers' Liability Insurance Company, of Great Britian. The report for 1903 shows that 14 and 12 per cent. of the breakdowns were due to accidents, the first figure being for dynamos and the second for motors; that 10 and 15.5 per cent. were attributed to dirt and oil; that 24 and 19 per cent. were the result of age and deterioration; that 3.5 and 5.5 per cent. rose from overloading; and 13 and 29.5 per cent. were not ascertained, the figures throughout being for dynamos and motors, respectively.

ALTERNATING CURRENT LABORATORY TESTING.

BY GEORGE H. ROWE.

PART I—CONTINUED.

WAVE ANALYSIS

In the preceding article the electromotive force was assumed to vary according to a simple harmonic law, and the resulting current was also assumed to vary according to the same law soon after closing the circuit.

The accuracy of this assumption may be studied by analysis of oscillograms of current and electromotive force taken from the various electrical machines in commercial use and under varying conditions of load.

In Figure 15 will be found oscillograms taken from a circuit in commercial operation. Any of these, however great the distortion, can be expressed in terms of functions of the fundamental frequency together with functions of multiples of the fundamental, or in other words, according to Fourier's Theorem* any periodic single valued function can be represented by the equation:

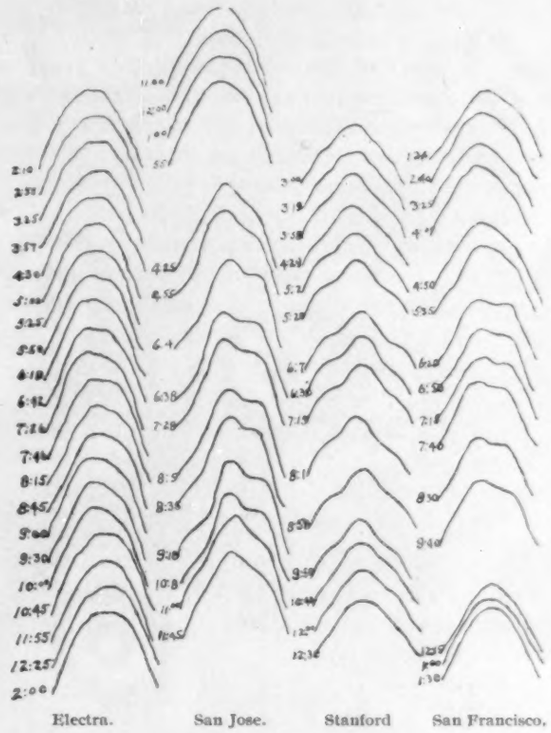


FIGURE 15

$$y = \tfrac{1}{2} A_0 + A_1 \sin \omega t + A_2 \sin 2\,\omega t + \ldots\ldots A_n \sin n\,\omega t + B_1 \cos \omega t + B_2 \cos 2\,\omega t + \ldots\ldots B_n \cos n\,\omega t$$

Since $\tfrac{1}{2} A_0$ is the mean ordinate, this constant term can be made to disappear by proper selection of the axis of reference. Also the value of A_n is well known to be:

$$A_n = \frac{1}{\pi} \int_0^{2\pi} y \sin n\,\omega t\, d\,\omega t, \text{ and}$$

$$B_n = \frac{1}{\pi} \int_0^{2\pi} y \cos n\,\omega t\, d\,\omega t.$$

*Byerly's Fourier's Series, Byerly's Calculus, Williamson's Calculus.

These integrals can be evaluated graphically*, algebraically or mechanically. Also any two coefficients A_n and B_n can be combined into an equivalent resultant R_n by the relation $R_n = \sqrt{A^2_n + B^2_n}$, the angle of phase difference of the n th harmonic referred to the zero of the given wave being $\tan^{-1} \frac{B_n}{A_n}$.

Hence we may determine that the curves marked Electra, Figure 15, are almost exactly represented by the equation $e = E$ max. $\sin \omega t$.

The wave marked 7:15, Stanford, is expressed by the equation:

$e = E$ max $[\sin (\omega t - 0^\circ\ 20') + .0366 \sin (3\ \omega t + 177^\circ\ 31') + .08 \sin (5\ \omega t - 29^\circ\ 15') + .0163 \sin (7\ \omega t - 90^\circ) + .0005 \sin (9\ \omega t - 90^\circ)]$

For the wave marked 7:28, San Jose, the equation is:

$e = E$ max $[\sin (\omega t - 17') + .097 \sin (3\ \omega t + 56^\circ\ 58') + .076 \sin (5\ \omega t + 180^\circ\ 6')]$

It will be seen that the electromotive force wave consists of components which are functions of the fundamental frequency and of the higher odd harmonics, the even harmonics being always absent. Obviously, before combining coefficients, we may write†

$e = E$ max. $[(A_1 + A_2 \ldots\ldots A_n) + j\ (B_1 + B_2 \ldots\ldots + B_n)]$

The current wave may be distorted even though the electromotive force impressed is a simple sine wave. This is shown in the current curve of Figure 16, which

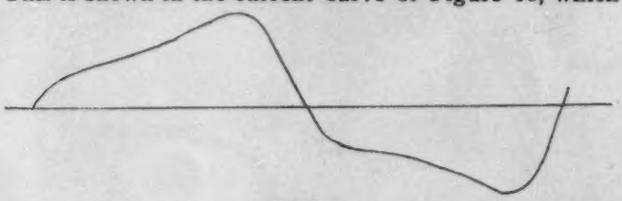


FIGURE 16

is similar to that shown in Figure 8. The variation from simple sine form has already been shown to be due to a variation of the inductive reactance or $L\omega$. The equation of the curve, Figure 16, is:

$i = I$ max. $[\sin (\omega t - 17^\circ\ 20') + .268 \sin (3\ \omega t + 29^\circ\ 30') + .0715 \sin (5\ \omega + 24^\circ\ 20')]$

In Figure 17 is shown an electromotive force wave of unitooth three-phase alternator given by Steinmetz. Its equation is:

$e = E$ max. $[\sin \omega t - .12 \sin (3\ \omega t - 2.3^\circ) - .23 \sin (5\ \omega t - 1.5^\circ) + .134 \sin (7\ \omega t - 6.2^\circ) - .002 \sin (9\ \omega t + 27.7^\circ) - .046 \sin (11\ \omega t - 5.5^\circ) + .031 \sin (13\ \omega t - 61.5^\circ)]$

Figure 18 is an electromotive force wave taken by Field‡ from a three-phase generator on cables possessing considerable capacity. The equation as analysed by the writer is:

$e = E$ max. $[\sin (\omega t + 4^\circ\ 55') + 0 \sin 3\ \omega t - .141 \sin (5\ \omega t - 6^\circ\ 40') + .313 \sin (7\ \omega t - 12^\circ\ 50') + \sin 9\ \omega t + .174 \sin (11\ \omega t + 63^\circ\ 25') - .077 \sin 0 (13\ \omega t - 83^\circ\ 5') + 0 \sin 15\ \omega t.]$

*Ryan, Hoxie and Norris, page 45; Houston and Kennelly's Alternating Currents; Kintner, *Electrical World*, May 28, 1904; Henrici Phil. Mag., Volume XXVIII, page 110.

†Phenomena, page 411.

‡London Institute Electrical Engineers, February 10, 1903.

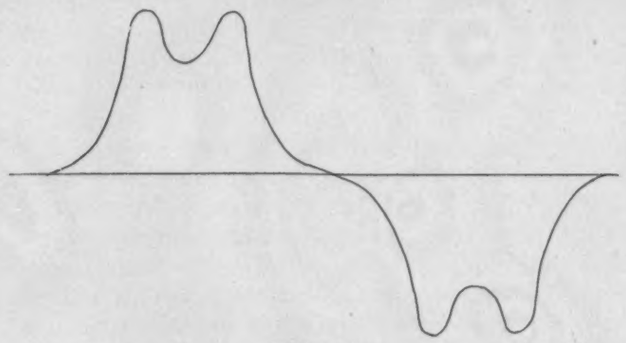


FIGURE 17

This equation shows that the fifth, seventh, eleventh and thirteenth harmonics originally small in the generator electromotive force wave have been increased by partial resonance.

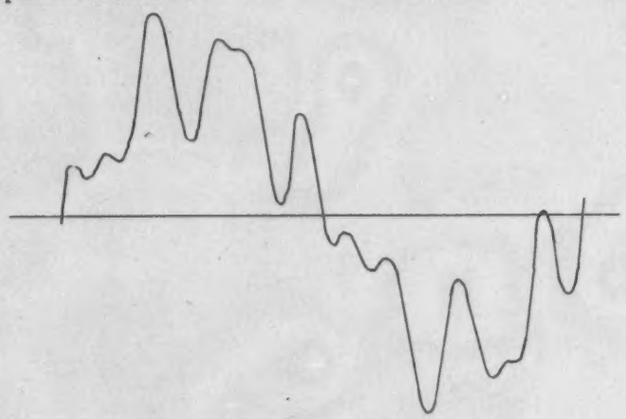


FIGURE 18

RESONANCE.

Assuming a fundamental frequency only, the current has already been shown to be

$$I = \frac{E}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

or this may be written as an electromotive force equation thus

$$E^2 = R^2 I^2 + \left(\omega L - \frac{1}{\omega C}\right)^2 I^2$$

Now, when $\omega L = \frac{1}{\omega C}$, the current enormously increases, being limited only by the resistance.

Also, $\omega L\ I$ and $\frac{1}{\omega C}$, that is the electromotive forces across the terminals of the inductance and capacity, respectively, may each exceed the electromotive force E, just as in the case of a weight suspended by a spiral spring, the forces acting on both spring and weight during oscillation are greater than the small force synchronously applied necessary to continue the oscillation.

Assuming a distorted pressure wave, the complete equation symbolically expressed becomes:

$$I = \frac{E \text{ max } [(A_1 + A_2 + \ldots A_n) + j\ (B_1 + B_2 + \ldots B_n)]}{v + j\ [(x_1 - x_1^1),\ (x_2 - x_2^1),\ \ldots\ (x_n - x_n^1)]}$$

x_n and x_n^1 being the magnetic and capacity reactance for any frequency n times the fundamental. Resonance of

any harmonic will, of course, occur when $x_n = x_n^1$. This effect is well shown in Figure 18.

FORM FACTOR.

In many cases* it is absolutely necessary to deal with the actual components, as in the preceding paragraph. In most practical work it is sufficient to express all electromotive forces and currents in terms of the fundamental frequency. In case of decided variation of the given wave form sine wave, we multiply the former by a form factor which gives a rough approximation to the amount of distortion. Form factor is defined to be the ratio of the average ordinate of the equivalent sine wave to the average ordinate of the given wave.

Square the ordinates of the given wave and find the area of the resulting curve by means of a planimeter. Find the square root of mean square ordinate a. This will correspond to the observed voltmeter reading. Determine the average ordinate of the given wave y. Then the average electromotive force will be $y \times \frac{\text{voltmeter reading}}{a}$. The average electromotive force of the equivalent sine wave will be:

$$\frac{\text{voltmeter reading} \times 2\sqrt{2}}{\pi}$$

Hence the form factor will be:

$$x = \frac{2\sqrt{2}\,a}{\pi\, y}$$

*Phenomena, pages 402 and 438.

Another method is that given in Steinmetz' Elements, page 115.

MAGNETIZATION CURVES.

Two methods have become standard for the determination of the magnetic properties of iron. These are the magnetometer method, and the ballistic galvanometer method. Both of these will be found described in Ewing's "Magnetic Induction in Iron and Other Metals."

The relation between the magnetomotive force, H, and the induction, B, is usually expressed by means of a B—H curve. It is frequently more convenient in testing and designing to refer to magnetization curves with the values of the induction B, per square inch, plotted as ordinates, and the ampere turns per inch (at) plotted as abscissæ. Figure 19 shows magnetization curves for cast iron, cast steel and sheet iron. To find the ampere turns required to magnetize any length of a sample to given density B, multiply the number of turns per inch for the given density by the mean length of the magnetic circuit of the sample. The total ampere turns required to produce a given density, B, in a magnetic circuit consisting of several different parts of different magnetic quality, will be found by adding together the ampere turns required for the various parts.

Magnetization curves taken by means of alternating current are of advantage for transformer and induction motor work. Curves taken by this method are free from error due to magnetic creeping. They are, on the other hand, not accurate for magnetic densities approaching

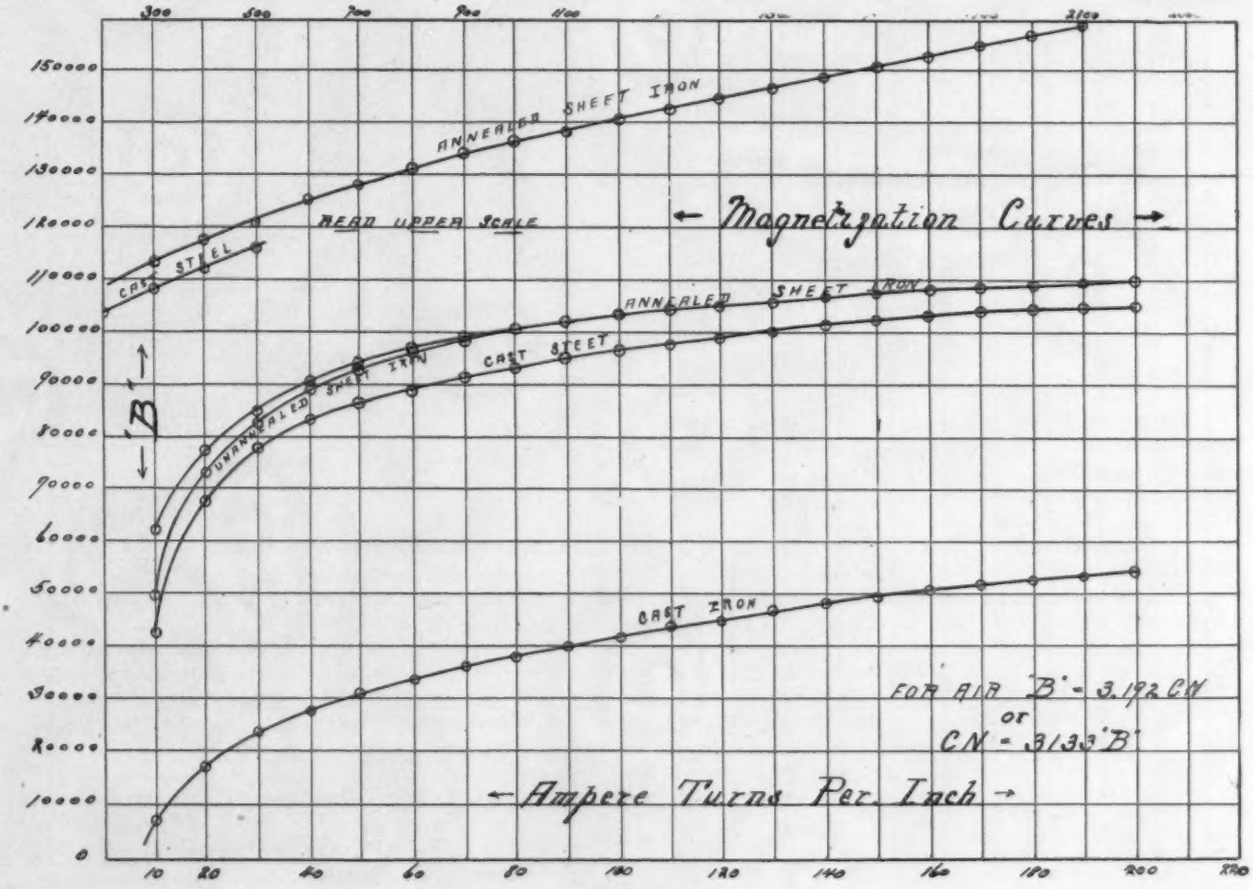


FIGURE 19

saturation. Densities in transformers and induction motors, however, seldom reach as great a density as 10,000 lines per square centimeter.

In a circuit containing iron the current is:

$I = \frac{E}{\sqrt{R^2 + \omega^2 L^2}}$, as already shown.

The electromotive force to overcome reactance is $\omega L I$. In a circuit containing a closed magnetic circuit or core, $\omega L I$ may be nearly equal to the impressed electromotive force, as may be seen from a consideration of Figure 9. If the circuit is not closed magnetically, the resistance drop may be considerable.

If the alternator supplies sine wave electromotive force its equation is $E = \frac{\sqrt{2}\,\pi\, T \sim \phi}{10^8}$ volts,*

where ϕ is the maximum flux, T the number of turns linking with the magnetic circuit, and $\sim$ is the frequency.

Therefore the electromotive force to overcome the counter electromotive force $\omega L I$ is:

$E_1 = \omega L I = \sqrt{E^2 - R^2 I^2} = \frac{\sqrt{2}\,\pi\, T \sim \phi}{10^8}$, from

which ϕ or $\frac{\phi}{A} = B$ can be found for various values of the impressed electromotive force E and the current I.

From Figure 9 and Figure 15 it will be seen that the current wave is distorted. If the iron under test is well laminated so as to minimize eddy currents, the current curve will reach its maximum value at the instant the flux reaches its maximum. It can also be shown that the maximum value of the distorted wave is almost exactly equal to the maximum value of the equivalent

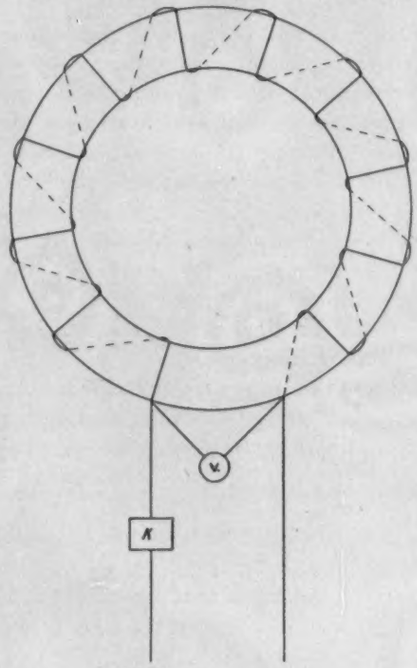
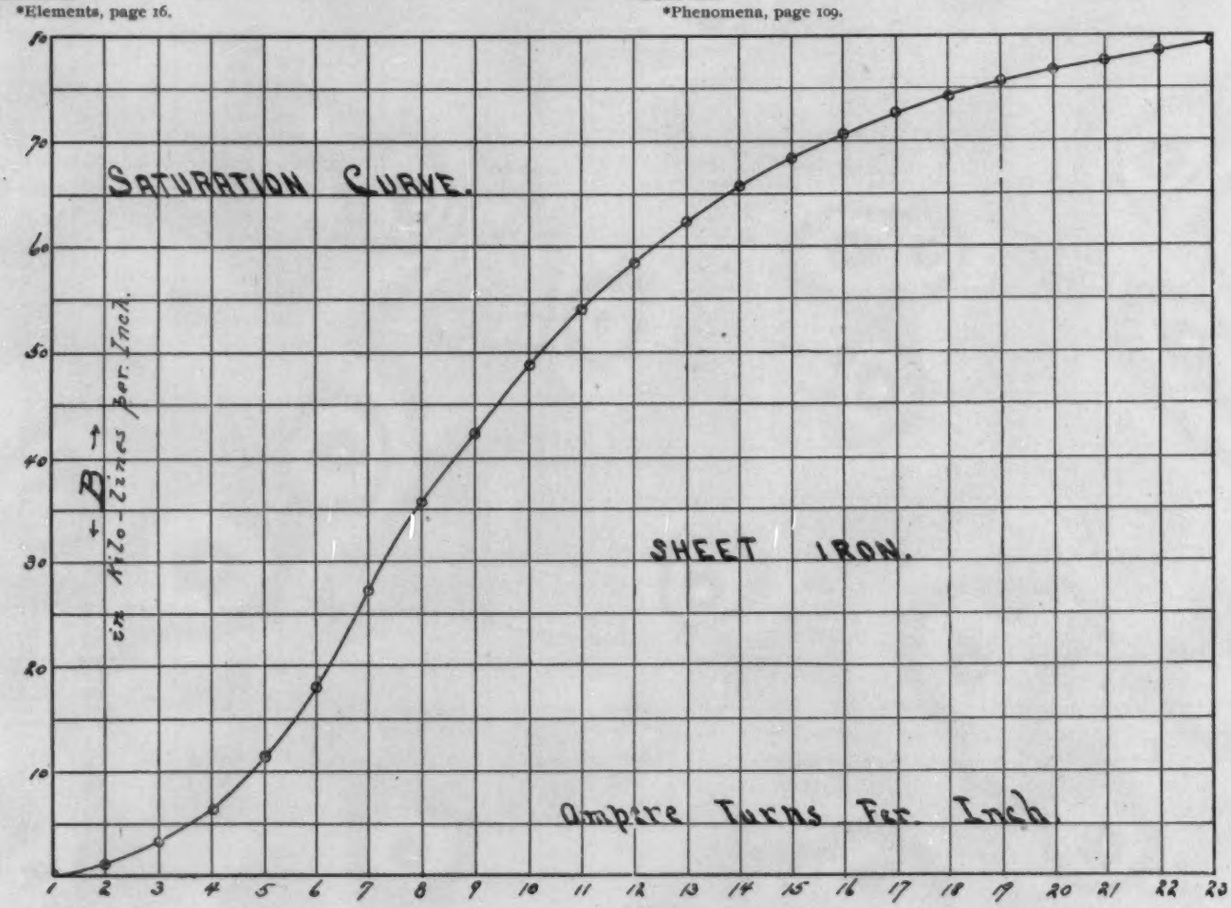


FIGURE 20

sine wave of current, for values of induction B, below saturation.* Therefore the maximum value of the cur-

*Elements, page 16.

*Phenomena, page 109.

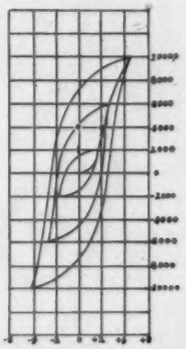


rent can be derived from the virtual value by multiplying by $\sqrt{2}$. Arrange the iron to be tested in the form of thin plates forming preferrably an entirely closed magnetic circuit. To avoid large eddy losses, the plates should be thin and separated by means of paper. A good thickness is ten to fifteen mils. The magnetomotive force will of course be $\frac{4\pi T I m}{10 l}$, where T is the number of turns in series, $I m$ is the maximum value of the current and l is the mean length of the magnetic circuit in centimeters. Connect as in Figure 20.

K is a Kelvin balance or delicate electro-dynamometer and V is a voltmeter measuring impressed electromotive force. Correction should be made for the current consumed by the voltmeter unless an electrostatic instrument is used. The following log will be useful:

Observed Read.			Calculated Read.			
E	I	Speed	E_1	B	$I m$	H

Plot B as ordinates and H as abscissæ or plot ampere turns per inch as in Figure 21. The maximum values



Hysteretic Cycle of Sheet Iron

FIGURE 22

of current should pass through the corners of the hysteresis areas as in Figure 22. As already shown, the exciting current $I ex$ is equal to the square root of the sum of the squares of the magnetizing and energy components.

(Continuation in next issue.)

CALIFORNIA'S PLACE IN EARLY ELECTRICAL HISTORY.

OF the distinctively pioneering work with which America is to be credited in the way of electrical invention and development, California is entitled to the first place in more than one important direction aside from that of the electric transmission of power, the claims for which have been so frequently exploited in these columns. Without doubt, the electrical engineer who is foremost in engineering development and who has since achieved the greatest national prominence in his chosen line was Stephen D. Field, now of Stockbridge, Mass., but with him were associated men whose names are probably more familiar locally, such as Messrs. Jno. I. Sabin, Orion Brooks,* Geo. S. Ladd, Wm. Lundberg, Jno. M. Klein and Paul Seiler. Mr. Field was, however, undoubtedly the leading spirit in this now historic work, and to him THE JOURNAL is indebted for the following information which cannot but be of more than passing interest as a contribution to the chronicles of early electrical history of the far West:

The first successful hotel electric annunciator in the United States was installed at the Grand Hotel in 1868.

The first multiple call district telegraph box originated in San Francisco.

The first central station for light and power in the United States was in San Francisco.

The first electrically illuminated theatrical representation in the United States took place at the California Theater.

The first police patrol telegraph was constructed by Engineer L. M. Clements in the snow sheds on the Sierra Nevada Mountains.

The first automatic ringer and the first selective signal in a telephone exchange originated in San Francisco.

The first dynamo plant for telegraph lines belongs to San Francisco.

The first long-distance telephone line was from French Corral to the summit of the Sierras, sixty miles, with twenty-four stations.

The first Patent Office record of the modern electric railway emanated from the patent agency of the *Mining and Scientific Press*, San Francisco.

In the year 1863 electrical developments on the Pacific Coast were entirely confined to the operations of the California State Telegraph Company. But three circuits entered the city of San Francisco, the same being composed of No. 9 iron wire, supported on redwood poles and insulated with Wale insulators. But two of these circuits could be worked at the same time, the "cross fire" between conductors rendering a separate pole line for each conductor a necessity. In those days every trouble was attributed to the fog, and the unvarying answer to any doubting remark as to the location of any disturbance was: "These fogs are peculiar. You don't have them in the East, you know."

With a view of clearing up the "cross fire" difficulty, George Hare of San Jose made an overland trip, testing the circuits every few miles. It was the duty of Mr. Field to watch out for him at the San Francisco end. The result of Mr. Hare's experiment showed that the "cross fire" existed to a serious extent in the small section of line between Mission Dolores and the main office on Montgomery Street in San Francisco. It is needless to add that the fog theorists received a severe setback, their discomfiture being all the more pronounced when it was determined that the brighter the day the greater the disturbance. Shortly afterward the trouble was completely removed by the simple expedient of placing a ground wire on each pole to carry off the leakage, and thus prevent a mingling of currents.

In the year 1865 the Fire Alarm Telegraph was introduced in San Francisco, and the year 1866 saw the writer installed as one of the operators of the system, at the Old City Hall, on Kearny Street. The following year the first private telegraph line was constructed for the firm of Kelly, Hewston & Co., between their office on Montgomery Street and their refinery on Brannan Street. The circuit was made of baling wire, about No. 14 plain iron, with a joint every 150 feet. The instruments, battery and dial ("A B C") were from C. T. and J. N. Chester & Co., of New York. The success of this line was so immediate that quite a demand sprang up for such installations, numbers of which were constructed by Mr. Field. The business was moderately profitable. The instruments cost $125 in greenbacks, rated at 50 to 80 cents on the dollar, and they sold in San Francisco at $250 each in gold. Housetop line construction cost $125 per mile, the pole line cost $250 per mile, and so on.

During the year 1868 W. C. Ralston erected the Grand Hotel and a contract was taken for the installation of electric bells throughout the building at the price of $18 per number. At that time there was not an electrical annunciator in operation in the United States, nor were there 500 feet of insulated bell

*See THE JOURNAL, Volume IX, pages 49 and 51, March, 1900.

wire in stock west of Omaha. The wire was procured from New York, as was also the annunciator, which was in operation as originally installed until four years ago.

Owing to a lack of experience in such installations, the cotton insulated wires were laid directly on the laths and imbedded in the plaster. As a natural consequence, about the time for the opening of the hotel it was discovered that every wire in the building caused leakage enough to hold its connected number displayed continuously when one tripped, but not quite enough current leaked to trip the number. The trouble was eliminated by a combination battery and relay system. A Daniels battery was kept constantly on the wires, and pushing in a button brought up the finely adjusted relay, which disconnected itself and its attached Daniels battery, substituting therefor a bichromate battery, which was powerful enough to drop the number and supply the leakage, at the same time restoring the drop by the lever devoted to such purpose, which momentarily broke the battery circuit and allowed all displayed numbers to "hang up."

Between 1868 and 1871 but little else was done in the electrical line save the installation of sundry private lines and electrical annunciators.

The year 1871 witnessed the incorporation of the Electrical Construction and Maintenance Company, which is now the California Electrical Works. About then Mr. Field resigned from the Fire Alarm Telegraph and was appointed electrician of the Pacific Division of the Western Union Telegraph Company, at the same time holding the position of electrician and secretary of the Electrical Construction and Maintenance Company. This company took over all the work which had formerly been done in outside electrical enterprises, and it also acquired by purchase the business of Lundberg* & Marwedel, who had been carrying on a small business in the manufacture of telegraph apparatus and supplies.

About the year 1874 the American District Telegraph system was introduced in San Francisco, the promoters being the various stockholders of the Electrical Construction and Maintenance Company, though the business was carried on under a separate incorporation. At the end of the first six months' operation it was found that the business just about paid expenses, the abnormal cost of operation being due to the great distances covered to obtain subscribers, which made the service time of the messengers so high as to be almost prohibitive. George S. Ladd conceived the idea that if a box could be contrived, by means of which the nature of a call could be automically sent in to a central office, a great economy of operation would ensue. Such a box was produced, with the result that its introduction enabled the District Telegraph Company to declare 1 per cent. per month dividends on a capital of $250,000, the total amount of actual capital invested being less than $20,000.

The year 1877 witnessed the introduction of the telephone on the Pacific Coast, the first exchange being opened in the District Telegraph office on Sansome street, San Francisco. This exchange was without doubt the first serious installation of this nature in the world. Among the pioneer elements of telephone combinations which were first brought out at this point were:

The annunciator as a central office call.

The automatically disconnecting peg switch, called the "jack-knife."

The cord connection between circuits.

The automatic ringer.

The selective signal, and last, but not least,

The first metallic telephone circuit.

This latter was the circuit to the Fire Patrol on Stevenson street from the main office on Sansome street, and originally it was equipped with a Phelps two-wire pointer. When the pointer was replaced by the telephone the ground connection was eliminated and the two live wires used as a metallic circuit. This was without doubt the first installation of all-metallic line connections in telephone work.

* For the biography of Mr. Lundberg see THE JOURNAL, Volume IX, page 70, April, 1900.

During the summer of 1878 the first long-distance telephone line was constructed for the North Bloomfield Gravel Mining Company and various other mining claims. Commencing at French Corral, in Yuba County, it extended to nearly the summit of the Sierra Nevada Mountains. The total length of the line was about sixty miles, and on it were connected twenty-four stations. This circuit worked without interruption until legal complications caused the shutting down of the mines.

During this same summer (1878) the first electric light station for light and power was opened on Market street, near Sansome. This was most noteworthy, as from this station the first outside distribution of electric light was effected. The California Theater and an auction house on Kearny street were lighted nightly, alternating currents and Jablockkoff candles being used at night, while during the day time currents from Gramme and Siemens machines were employed in propelling the stock tickers of the Gold and Stock Telegraph Company, as well as in operating an electric elevator at the central station on Market street. These demonstrations and installations commenced in the autumn of 1878 and continued during the winter of 1878–79.*

The modern Police Patrol Telegraph system, now so universally adopted in large cities, is identical with an installation designed by Engineer L. M. Clements of the Southern Pacific Railroad Company, and introduced through the snow sheds in the Sierra Nevadas. Each station comprised a multiple call district telegraph box arranged to transmit various predetermined signals, such as "Watchman going east," "Going west," "Shed out of line," "Rock on track," "Fire," "Use telephone." Besides the multiple call box, each station was provided with a telephone for the transmission of intelligence other than that arranged on the dial of the signal box. These elements in combination form the modern Police Patrol Telegraph, and Mr. Clements' conception and actual execution of the scheme so far antedates any other claimants as originators of the system as to put them out of consideration.

At the electric light station on Market Street above mentioned was carried out the experiments in power transmission which resulted in the first official Patent Office record of the modern trolley railway and electrical elevator; also the adaptation of the dynamo to telegraph working.

It is somewhat amusing to occasionally see how old straw is threshed over. Take, for instance, the matter of pins for high-tension insulators. In 1871 a big kettle, placed in the back yard of the Western Union Telegraph Company's office, was filled with paraffine oil, in which was boiled insulator pins until they ceased to give off bubbles. Then, when they had been removed from the oil and nearly cool, they were dipped repeatedly in paraffine, thus giving them a fine, smooth coating. They were then wrapped in tissue paper and in that state delivered on the line.

The first selective signal applied to a telephone circuit was installed during the summer of 1877. It consisted of a polarized relay placed in the line leading from the main office to the California Electrical Works on Sutter Street. Current of one polarity caused the bell to ring at the electrical works, while the other polarity called up a station further up the line on Kearny Street.

The first automatic ringer was a polarized vibrator that was constantly sending slow reversals from a battery. The apparatus was designed to actuate polarized as well as direct-current bells. In this it was eminently successful.

From the first the San Francisco telephone installation consisted of subsidiary stations. Thus the main office, being at 220 Sansome Street, was connected by trunk lines with sub-offices at Sutter and Leavenworth and on Polk Street, near California, precisely in the same manner as is now universally adopted. The San Francisco exchanges were all in operation long before the introduction of carbon transmitters and pretty good work was done, even with the ordinary magnetic telephone.

It may be interesting to note that even at the early date instanced above district telegraph subscribers obtained telephone

*See THE JOURNAL, Volume IX, page 49, March, 1900.

service by means of a magnet, telephone connected with the main office, through a condenser running to earth on the metallic circuit of the district signalling system, in a method not unlike some of the operations incident to the modern "common battery" installations. In these instances a call on the district box was devoted to notifying the central office to answer on the telephone.

In conclusion, Mr. Field recalled the fact that in 1878 a certain person lost much reputation among business men by reason of a written opinion to the effect that electric light and power in the city of San Francisco could be reasonably expected to earn 6 per cent. on a capital of $250,000.

The work instanced was mostly performed Mr. Field's own hands, and, taking the data and meagre facilities then available, he need be in no way ashamed of it. Many is the electro-magnet which was constructed with helices of bare copper wire, insulated with a coating of asphaltum varnish. Miles of line were hung up, the conductors of which consisted of ordinary baling wire, full of splits and joints, but all of the latter were religiously cut out and soldered. On the long-distance telephone line instanced forty of the sixty miles of run was entirely on trees, for which a peculiar type of swinging insulator was adopted.

When this line was finished the impedance of the relay coils rendered it inoperative. Mr. Field went over the line on foot and horseback, and by multiple arcing the relay coils a remedy was found, which many years later was heralded as a wonderful discovery.

Another feature connected with the circuit would have gladdened the heart of Marconi. Being miles away from any other electrical conductor a quiet line was anticipated; but such a bedlam! Dots and dashes, sighing, whistling—in fact, almost every kind of sound was continuously present. It only required the active imagination of the modern wireless promoter to have produced a message from Mars.

THE SINGLE PHASE EQUIPMENT OF THE INDIANAPOLIS AND CINCINNATI TRACTION COMPANY.

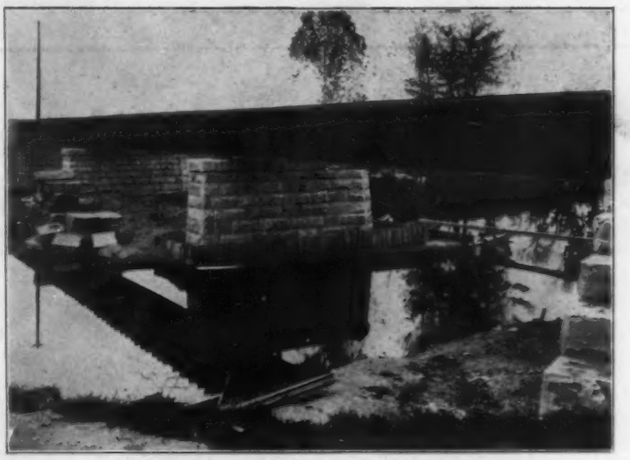
THE opening of the present year marks the beginning of a new era in electric transportation for it finds the alternating current railway system a commercial reality. The first regular service with a single-phase car was inaugurated in the city of Rushville, Ind., on the 30th of December, 1904, and since that date has been maintained and extended. To the Indianapolis and Cincinnati Traction Company belong the glory and honor due the pioneer, and to President Henry and his enterprising associates, and to Sargent and Lundy, the consulting engineers, are due the thanks of the engineering public. Their sagacity and foresight appreciated the importance of the new development and they possess the commercial courage so necessary to the highest success in this age of rapid progress.

The dominant idea in the minds of the originators of the company named was to build a double track through line from Indianapolis to Cincinnati, which would take care of the traffic between these two cities in a more satisfactory way than is now done by the steam roads. To this end the company has secured a most desirable private right of way. Where the land is level and there are no considerable fills or cuts, a right of way four rods wide has been purchased, but wherever a considerable fill or cut has been necessary additional width of right of way has been secured. In all the smaller towns a private right of way has been continued through, and the road is not constructed upon streets or highways except in cities or towns of such size as to make it necessary. In all cases inconvenient curves are avoided, and such an alignment has been secured between cities and towns as will permit of very rapid running with entire safety to passengers and equipment.

In most instances the right of way is protected by a woven wire fence erected under an agreement with the landowner whereby the landowner maintains the fence and keeps all its gates closed. Wherever such an agreement was not secured the right of way is fenced with barbed wire. In most cases the deeds of conveyance also provide that the company has a right to cut and keep any timber on adjacent lands that might interfere with wires or fencing or with the operation of the railroad.

Under the provision of the franchise of the Indianapolis Traction Terminal Company, interurban lines are allowed to enter the city over the tracks of the city company by such routes as the city designates upon payment to the city company of an agreed or ascertained compensation. The Indianapolis Traction and Terminal Company has made a uniform agreement with interurban roads for entrance into the city over its tracks, whereby interurban roads pay 4 cents for each passenger carried on the interurban cars while on the city lines, and this entitles them to all of the privileges of the terminal station where all the interurban roads center.

The Indianapolis and Cincinnati Traction Company has franchises in all of the cities and towns in Indiana through which the line passes, giving to it the most favored franchises within the State. They uniformly run for a period of fifty years, and contain no objectionable provisions regarding the pavement of streets, the erection of iron poles or the payment of a certain franchise tax to the State or town. The franchises of the cities of Rushville and Connorsville permit of running limited cars, making only one stop in each city. In all smaller towns the franchises also provide for the carrying of freight, express and mail matter under reasonable regulations of the various cities and towns, so that the company confidently expects a large income from this source. All



OVERHEAD CROSSING AT NEW PALESTINE, IND.

private rights of way and franchises outside of the cities and towns run in perpetuity. The line has already been constructed between Indianapolis and Rushville, a distance of forty-one miles, and a through service between those towns will soon be established. At an early date the road will be extended to Connorsville.

The construction of the roadway is thoroughly first-class and is equal to that of any line in the country. The track is graded in accordance with the best practice for steam roads, cuts and fills being made so as to avoid excessive or frequent grades. Between Indianapolis and a point eight miles east of Rushville—a distance of nearly fifty miles—there is no grade exceeding 1½ per cent. From that point on towards Cincinnati the country is less level and in some cases straight lines have been preferred, even at the expense of some increase in grades; but with the aligment and grade considered together, greater speed can be obtained with comfort and safety to passengers than on any steam road now running between Indianapolis and Cincinnati. So far as the profile of the road has been as yet determined the heaviest grade will be 4 per cent. and it is believed that no greater grade will be necessary on the entire line.

The roadbed is graded twenty-eight feet wide on top for a double track, with slopes on fills and in cuts of 1½ to 1, and upon a grade line that puts the track in most instances above the level of adacent lands, so as to avoid trouble on account of snow. The

bridges across all streams are constructed in the most approved manner, either with concrete arches or steel girders with stone abuttments. The upper structures are built of the very best steel construction by the Indiana Bridge Company, of Muncie, Ind., of a capacity sufficient to carry a train of cars with a gross weight of one hundred tons for each car. All abuttments are built for double track—the superstructures at this time are laid for one track only. It will be noted that provision is made for the increased demand for size of cars and length of trains likely to come in the near future.

The road is laid with double track in the city of Rushville and on all highways; but on the private right of way, while the grade is prepared for double track, only one has been laid, as a second

OVERHEAD CROSSING AT NEW PALESTINE, IND.

track can be more conveniently and economically put down later, when a sufficient portion of the road is in operation to require a double track. All ties used are first-class—no culls or seconds—white oak, burr oak, and a few chestnuts, six inches by eight inches by eight feet long, 3280 to the mile. The bridge ties are of long leaf yellow pine.

The track is laid with seventy pounds T rail, in sixty foot lengths, connected with Weber rail joints, and bonded at the joints with No. 0000 ten-inch copper bonds, with seven-eighths-inch terminals under the plate so as not to be exposed. Cross bonds are put in every half mile and long bonds under all special work. The switches and other special work have been furnished by the Buda Foundry and Manufacturing Company, of Chicago, and are built according to steam railway standards. Turn-outs and cross-overs are constructed so as to avoid danger of open switches. The road is to be ballasted with gravel eight inches under the ties and level with the top of the rail. In the streets of Rushville an eight-inch layer of broken stone was placed under its ties.

The trolley wire is suspended along the private right of way from poles set in the center of the grade one hundred feet apart, with a bracket made of angle iron looped at the end so as to carry a large flat porcelain insulator, from the top of which is run a seven-sixteenths-inch steel strand cable or "messenger" wire. The No. 000 grooved copper trolley wire is carried eight inches under the messenger cable, to which it is attached every ten feet with especially made steel clamps, a construction known as the catenary suspension. The steel messenger wire is drawn tight. With this construction danger from trolley breaks is reduced to a minimum. The insulators are large and strong and are not likely to break, but if they should the steel cable would remain suspended from the top of the bracket. As the trolley is attached to the steel cable every ten feet breaks will be very infrequent, and if one should occur, not more than ten feet of the trolley would be loose. The catenary construction provides a practically level trolley with no sudden bends at the insulators as is found with the ordinary suspension, a point which is of great advantage to fast running cars. The trolley wire is suspended eighteen feet above the top of the rail.

Where the tracks are in the streets the poles are set on the sides of the streets and the trolley is suspended from span wires. Otherwise the construction is the same as along the private right of way. The overhead material for the entire line construction was supplied by the Westinghouse Electric and Manufacturing Company according to the design of Sargent & Lundy, consulting enineres.

The system of electrical distribution requires transformer stations about ten or twelve miles apart, and the alternating current is transmitted from the power house to these transformer stations at 33,000 volts. single-phase, twenty-five cycles per second, and is reduced and fed into the trolley at a potential of 3300 volts. The high tension current is carried from the central power station to the transformer stations on No. 4 bare copper wires, two wires to each transformer station. They make a complete circuit and permit the placing of the circuit-breakers and switches at the central power house so as to do away with the necessity of attendants at the transformer stations. The high tension lines are carried on a seperate line of poles set near the edge of the right of way, provided with carefully and strongly constructed cross-arms and equipped with large porcelain insulators on iron pins.

The entire system is provided with two metallic circuit (four copper wires) telephone lines, one of which is used exclusively by the train dispatcher. The other line is used for general company business. Each car is provided with a telephone, by means of which the conductor can talk with the train dispatcher at fixed points. Jack boxes are placed on the poles at intervals of 2000 feet, from any of which the conductor of a car or any one else with a telephone can call up to report an accident or for any other purpose. The four telephone wires are carried by porcelain insulators on cross-arms near the top of the trolley poles, and are thus far removed from the high tension lines. The wires are transposes every 500 feet in order to avoid disturbances from the current in the transmission lines.

The poles are all of select white cedar. Those for the center trolley construction are forty feet long with seven-inch top. The side poles for the high tension lines are thirty-five feet long with seven-inch top. All are set six feet in the ground and are carefully tamped. Along streets on the side where there are no feed wires and the poles are used only to support the span wire thirty-

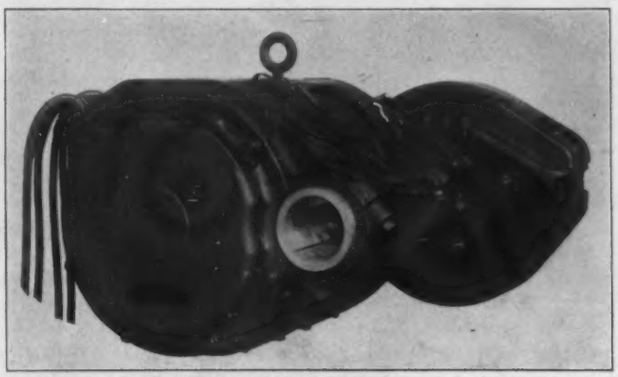
FIFTEEN-FOOT CONCRETE ARCH NEAR JULIETTA, IND.

foot poles are used, while on the other side where the high tension line runs the poles are of varying height from forty feet to sixty feet, so as to carry the feed wires above the shade trees. All of the side poles along the streets are neatly shaved and painted and are set in concrete. The tall sixty-foot poles are of Idaho cedar—beautiful, smooth and straight as if turned in a lathe. The entire pole line was constructed under the direction of A. A. Anderson, general superintendent of the Indianapolis and Cincinnati

Traction Company, and under the immediate supervision of Foreman Oscar D. Emery. The work is of such excellent character throughout as to attract the attention of even casual observers, and among experienced linemen it is conceded to be superior in substantial character and artistic appearance to any other line in the country.

Within the limits of the city of Indianapolis, a distance of approximately three miles, the cars will be run over already existing lines, and will be operated by direct current at 550 volts. Within the limits of the city of Rushville they will be operated by alternating current at the same potential; on intervening sections the trolley will be fed by alternating current at 3300 volts, twenty-five cycles per second, single phase. Thus the first single phase railway exemplifies the possibility of operating the same equipment from both direct and alternating current lines and illustrates the voltage flexibility of the system, one of its most advantageous features. The power station from which it is intended to operate the entire road is located at Rushville. From this plant 33,000-volt transmission circuits are run to the points of transformation and there reduced to 3300 volts before connection to the trolley.

As has been stated, the road is divided into sections of ten or twelve miles, each of which is supplied with current from a transformer station. Three such stations have been erected between Indianapolis and Rushville, by Pulse & Porter, contractors, of Greensburg, Indiana. The transformer houses are very small,



WESTINGHOUSE SEVENTY-FIVE HORSEPOWER, ALTERNATING CURRENT, SINGLE-PHASE, SERIES WOUND RAILWAY MOTOR

measuring but twenty-one feet by twenty-three feet, but are carefully and substantially built. The foundations are of concrete; the walls are of brick laid in cement mortar and the floors for both the first and second stories are of concrete upon steel beams. The roof is built upon concrete base. The doors and windows are provided with steel shutters, and the whole structure is made thoroughly fire-proof and can be closed and left alone with safety.

In each of the transformer stations there are at present installed two 300 kilowatt oil-insulated step-down transformers, 33,000 to 3300 volts. Space has been provided for an additional transformer of the same capacity. On the second floor of each transformer station there are installed the lightning arresters and disconnecting switches. There are no automatic switches of any type in these stations, as they are controlled only through the switchboard in the power station. There is nothing at the station which requires constant attention, and only occasional inspection will be necessary. This does away entirely with the expense usually incident to the substation of other systems, which usually amounts to the wages of three men at each substation, aggregating not less than $8.00 per day. The annual saving in wages on the three transformer stations between Indianapolis and Rushville made possible by the alternating current system amounts therefore to $6,570, or a total annual saving on the ten transformer stations between Indianapolis to Cincinnati in wages alone of $21,900. In addition to this, there will be a large amount saved in the maintenance and repair of machinery.

The entire electrical equipment of the transformer stations was furnished by the Westinghouse Electric and Manufacturing Company, and was installed under the supervision of Sargent & Lundy The disconnecting switches were made from a design specially prepared for this service by Sargent & Lundy.

The power house serves as an additional transformer station and contains two 300-kilowatt lowering transformers, wound for 3300 volts primary and 550 volts secondary circuits, which are used to feed that portion of trolley included within the limits of the city of Rushville.

The two-phase power circuit indicated is a provision for a four-wire power circuit, which it is proposed to run from the power house in Rushville to the electric line between Indianapolis and Shelbyville, which is at present operated by direct current from its own power house through rotary converter substations and direct-current railway motors.

The power house, which is located at Rushville, Indiana, is a strictly fire-proof building of brick, concrete and steel, with rooms well lighted and skilfully arranged for future addition and enlargment. The site is adjacent to the C. H. & D. Railway with a connecting track from that road to the company's track alongside of the power station. The boiler room occupies one side of the building and is at present equipped with three 300 horsepower Babcock & Wilcox boilers. Natural gas is now being used for fuel, but provision is made for the burning of coal if at any time the supply of gas becomes insufficient. The engine room occupies the other side of the building and is seperated into two parts by a heavy brick partition. In the main room are installed the two generator units which consist of a 500-kilowatt Westinghouse revolving field alternator, twenty-five cycles per second, direct-connecting to a 700 horsepower Corliss type, cross compound, condensing engine, built by the Fulton Iron Works, of St. Louis, Mo. Both engines and generators are designed for a overload capacity of 50 per cent. Each engine is equipped with an independent jet condenser, made by the Dean Bros. Steam Pump Works, of Indianapolis, which take their water from an underground tunnel connecting to a large mill race. Two pairs of 250-kilowatt air-blast transformers are arranged to change the current which comes from the generator at 2300 volts three-phase, to 33,000 volts, two-phase, for transmission to the transformer stations along the line. Air for these transformers is supplied by two motor-driven blowers. The generator field is excited by direct current generators, one of which is direct connected to an alternating current type C Westinghouse induction motor; the other to a Westinghouse compound steam engine. The marble switchboard controlling panels are also located in this main engine room, and the controlling apparatus is installed in the other portion of the building which is known as the high tension chamber. The main busbars are located in the basement and are supported upon a masonary structure and separated by barriers of alberine stone.

The power house was built according to plans and specifications of the consulting engineers, Sargent & Lundy, and all of the equipment was purchased under the specifications and installed under their supervision.

Each car is equipped with two trolleys, one of the Union Standard type with trolley wheel, to be used when operating from the direct.current lines in Indianapolis or from the low-voltage, alternating-current lines in Rushville; the second trolley is of the bow, high speed type, and has been designed for service at 3300 volts, alternating current. It is confidently believed that with the high-voltage, alternating-current trolley wire and the sliding contact bow trolley adopted by this company that heavy freight can be hauled advantageously without experiencing those difficulties heretofore encountered when service of this kind has been attempted on the direct-current system.

Local cars are operated each way every hour, making stops upon signals at all of the cities and towns and at the principal crossings of the country. These cars are all provided with compartments in which baggage and light express matter may be

carried. They are designed to run at a scheduled speed of thirty miles per hour. To properly take care of through service, additional "limited" cars will be put on the line; each of these will be equipped with four 150 horsepower motors designed to operate at a schedule speed of fifty or sixty miles per hour, as under the provisions of the various franchises they will not have to make any stops in the country or at any of the smaller towns and will only be required to make one stop at each of the larger intervening cities. It is expected that when the road is completed from Indianapolis to Cincinnati these "limited" cars will be able to make the trip from the center of one city to the center of the other in three hours time.

This road has been built in every detail with a view to the handling of heavy freight, even to the extent of carrying it in long trains. Whenever in the intervening cities short radius curves could not be otherwise avoided, the private property of the inside corner has been purchased and the sidewalks and curbs set back so as to make easy curves and permit the handling of heavy trains.

The most interesting feature of the new installation is the absence of rotary transformer substations and the small amount of feeder copper used. It should be noted that in the trolley line, which is composed of No. 000 copper wire, no feeder circuit is necessary other than the No. 4 high potential transmission line which carries the current from the power house to the transforming points.

A SEARCH LIGHT FOR MOUNT HOOD.

BY FRANK L. MERRICK.

ENTER the Lewis and Clark Exposition grounds some night next summer, pass through Columbia Court, the central plaza of the Western World's Fair, look out over the glimmering waters of Guild's Lake, reflecting thousands of electric lights, and see many miles in the distance a snow-capped mountain peak, bathed in white splendor rising out of the darkness in all of its pictorial grandeur. The effect is startling.

Astonishment is increased when the glowing peak fades away and a streak of light shoots across the sky, suddenly stops and another mountain covered with snow looms up out of the night many miles from the first. Then one looks to see where the light comes from and sees still another frosted peak standing out this time in irridescent brightness, with a white beam shooting across the heavens from its highest point.

This enchanting picture is only one of the many surprises in store for the visitor to the Portland Fair. Incredible as it may appear, nevertheless the presentation of such a unique effect is practicable, and the chief electrical engineer of the Exposition, J. R. Thompson, is now perfecting the plans for this feature of the night displays at the Centennial.

Four snow-capped mountains can be seen from the Exposition grounds on a clear day. These are Mt. Hood, Mt. St. Helens, Mt. Rainer and Mt. Adams. The plan is to place a searchlight with an eighty-inch projector on the crest of Mt. Hood, which is 11,225 feet above the sea level and forty-six miles from Portland. This searchlight from its commanding position will pierce the darkness for 200 miles and its gleam on the nearby peaks will be startling. Its flash on Mt. Ranier, which is 100 miles from Mt. Hood, could be seen from the cities bordering on Puget Sound, such as Seattle and Tacoma. From vessels off the coast 120 miles distant the flashes could be seen plainly on a clear night and at Portland and the Exposition grounds the gleams would be very strong.

Mt. Hood is the pride of Portlanders. Its lofty peak may be seen from the city streets and late in the afternoon when the rays of the setting sun bathe it in the Alpine glow one may see visitors standing on the corners and gazing at it in enraptured admiration. Mountain climbing among the great peaks which are near the Exposition city and which rival the Alps in grandeur, is not such a serious undertaking, as regards time and expense, as it may seem. By taking a morning train to Hood River, and a stage which runs daily to Cloud Cap Inn, 6800 feet up the mountain side and twenty-six miles from Hood River, one arrives at the Inn in the evening. After spending the night at the comfortable hostlery on the edge of the snow-covered mountain with glaciers surrounding it, one may climb the peak in the morning and be back in Portland that evening. Two days and a night are consumed by the trip and the total cost is less than $20.

To place the searchlight on Mt. Hood requires quite a bit of engineering skill and labor which will cost about $30,000. A short tower of wood and iron, the upper part for the searchlight and the base for the apparatus and operators, will be built on the summit. The transmission line has to be built down the north side of the mountain to Cooper's Spur and from there to a point in the neighborhood of Cloud Cap Inn, where a temporary generating plant will be installed. The construction of the tower and the delivery of the necessary material and apparatus are the difficult parts of the construction work. This will be overcome by the use of a steel hoisting cable and sleds, and all of the material can be delivered on the summit by this means, as the side of the mountain toward Cloud Cap Inn is favorable to this mode of transportation. The sleds will be run over the trail used yearly by the mountain climbers.

Parts of the transmission line will have to be carried over glaciers and special construction will be necessary for this work. Iron poles painted white so as not to absorb any heat will be placed in the ice to carry the cables.

A flat surface on the summit of the mountain has been selected as the site for the tower. Here the debris will have to be cleared away and the engineers will have to blast for solid foundations. The tower will be erected on iron posts sunk in the ice and will be composed of wood, iron and steel. In order to protect the operators from the severe cold of the mountain at night the transformers and motors will be arranged so that they can be controlled from the operating room. After the sun goes down everything on Hood freezes solid.

In addition to the searchlight effect from the summit, the establishment of the apparatus affords means for a general illumination of the mountain by arc lights. One hundred arc lights equal to those used to light the streets of a city will be distributed on the side of the mountain facing Portland. Besides the use of the searchlight and arc lights red fire will be used in great quantities and several times each evening the mountain will have the appearence of a Vesuvius. This latter feature has been tried several times by the people of Portland and the effect produced was beyond description. Fifty pounds of red powder were used and the whole side of the mountain looked like it was on fire.

The placing of the tower on Mt. Hood may be the beginning of a movement for the establishment of an astronomical observatory on this majestic peak of the Cascade Range.

WHERE CALIFORNIA RANKS.

SOME idea of the important plane which the State of California occupies in the sphere of electrical development is conveyed in United States Census Bulletin No. 5, dated November 30, 1903, from which it appears that California, standing twenty-first in point of population among the United States, ranks as tenth in the number of electric central stations operated, and that these stations derive a total income which gives them the seventh place. The fifth place is held from the standpoint of income from income from incandescent electric lighting service, the seventh place from the standpoint of arc lighting income, and as to the income derived from the sale of electro-motive power, California is proudly second, being exceeded by a few per cent. only by the State of New York, with Illinois a bad third, being some 40 per cent. behind California.

Portland, Oregon, where the Lewis and Clark Exposition is to be held next summer, now has a population of 136,000. When the popu'ation did not exceed 100,000 the citizens subscribed $430,000 to to the Fair.

Use of Pacific Coast Water Powers in Electrical Operation of Railroads.*

BY ROBERT McF. DOBLE.

DURING the last few years much has been done in the direction of applying electricity as motive power to replace steam locomotives on railroads, and to-day the subject is deemed most important and is receiving the serious consideration of our brightest engineers and railroad men.

Perhaps the largest undertakings of this kind are the new systems and locomotives to be installed on the New York terminals of the New York Central and the Pennsylvania railroads. Although the system selected to be used there is specially suited to short distances where the traffic is extremely dense and where trains are operated at frequent intervals, the fact that two of the largest railroad corporations in the United States have made exhaustive investigations of the subject of electric traction and are preparing to make such enormous expenditures for the improvements attracts the attention of every steam railroad man in the country. It is timely, therefore, to review what advance has been made in electric traction and to consider what possibilities there are for its introduction on the railroads of the Pacific Coast, and the utilization therefore of the many water powers which are available.

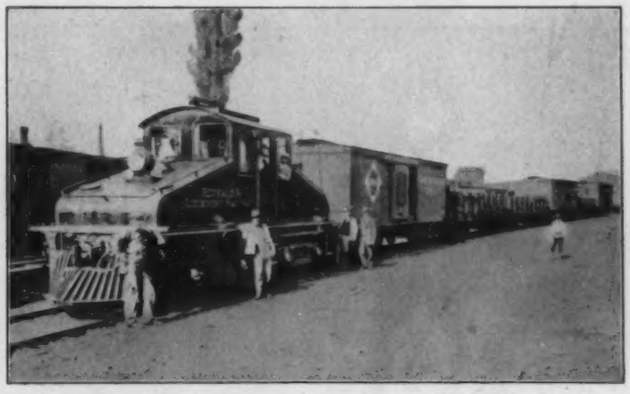


FIGURE 1. A 96-TON ELECTRIC LOCOMOTIVE, BUFFALO AND LOCKPORT RAILWAY

The advantages of electric traction over steam for the operation of railroads will be treated under three general heads, *viz.*:

First—Those which appeal to the passenger and which result in an increase of traffic;

Second—Those relating to the operation of trains from a central source of power; and

NOTE—Indebtedness is acknowledged to the *Electrical World and Engineer* for figures 7 and 14.

Third—The economies in first cost, maintenance and operating expenses.

The most important advantages of electric traction to the passengers, or at least those most noticeable at first sight, are those which appeal to their comfort. Under this classification may be noted the freedom from dirt, smoke and cinders, particularly in tunnels, train sheds, snow sheds and other places where smoke is confined. The cleanliness of electric cars always makes a good impression on the passengers. There is also better ventilation and lighting and the heating of cars electrically is a decided advantage, as a uniform temperature is more easily maintained.

Another factor of benefit to the passenger, although not necessarily tending to his comfort in riding, is the higher speed possible with trains electrically operated. Not only can high speeds be obtained for continuous runs, but with the same running speed as on a steam line, the average speed is higher and the duration of the trip is considerably reduced on account of the more rapid starting and stopping. This is made possible by the increased traction due to the uniform rotary movement of the motors. There is not the tendency to slip at certain points of the revolution as noticed with steam locomotives. It has been estimated that from 25 to 30 per cent. of the weight of an electric locomotive can be utilized as draw-bar pull, while actual tests have shown that as high as 33 per cent. can be so used. Compared with these figures are coefficients ranging from only 13 to 16 per cent. for the most powerful steam locomotive built. These figures are based on the ratio of the maximum draw-bar pull to the total weight of the locomotive. Considering the comparative weights on the drivers in each case we find that the electric locomotive shows an increase over the steam of from 10 to 20 per cent.

The greater weight possible on the driving wheels with electric traction is an important factor. Usually the total weight of the train should not exceed 7 to 10 per cent. of the weight on the drivers of a steam locomotive. This is increased in the cars of an electric locomotive to from 15 to 26 per cent. while with a multiple-unit system, where one-half the cars are equipped with motors on each axle, approximately 55 per cent. of the train weight rests on the driving wheels. In the case of a multiple-unit system, with motors on all of the axles, 100 per cent. of the total weight of the train is available for traction.

Those factors of greater tractive effort and greater weight on the drivers make possible higher rates of acceleration than with steam, thus resulting in a higher average speed of trains making frequent stops. The braking acceleration is also greater because the coefficient of adhesion on the rails is greater than with a steam locomotive. These conditions make possible the operation of trains under short headway and with a decrease in the time of the trip, both of which factors are essential to successful commercial results, especially on short suburban lines. An additional gain in running

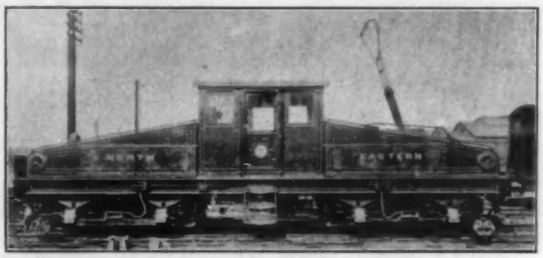


FIGURE 2. ELECTRIC LOCOMOTIVE WITH BOW COLLECTOR AND THIRD-RAIL SHOES, NORTHEASTERN RAILWAY

*A paper well illustrated with stereopticon views and diagrams that was read before the Pacific Coast Railway Club, at San Francisco, on January 21, 1905, and revised for THE JOURNAL by the author.

time is also secured by electric trains on lines of considerable length since no stops are necessary to take in a water or fuel supply.

Higher sustained speeds are also made possible by electric traction, as has been conclusively demonstrated by the Berlin-Zossen trials in Germany. Here experimental speeds were gradually worked up to as high as 130 miles an hour. However, such extremely high speeds are out of the question for commercial operation, for the present at least, on account of the great cost. The present maximum speeds of steam trains are great enough for comfort and are apt not to be exceeded by electric trains except in special instances where there are enough passengers to pay increased traffic rates in order to save time.

With the multiple-unit system, which dispenses with the locomotive, the number of cars per train can very easily be arranged to suit the traffic without changing the number of trains—an important advantage under certain conditions, as where sidings and switching facilities are limited. With trains running under close headway two or more trains can be coupled together and operated as one unit. An example of this may be seen on the Key Route during times of heavy fogs, when the Berkeley and Piedmont trains, west bound, are coupled together at San Pablo Avenue, and run as a single train to the ferry station at the end of the pier, thus avoiding any possibility of collision.

In considering the operation of a railway system from a central power station, where water power is available, the question naturally divides itself between the use of steam and water power.

The economy of producing power in a large central station, due to the refinements in steam generation and consumption as well as to the high load factor, becomes more apparent to the disadvantage of the customary locomotive units as the cost of fuel increases. The possibility of using an inferior grade of coal, especially when it can be mined near the power station is noteworthy. However, even with these advantages, in the present state of the art, it is doubtful if the introduction of electric traction will be commercially profitable on trunk lines, with infrequent trains, if central steam power plants are to be depended on. For the present, the field for heavy electric traction under these conditions seems to be for the operation of terminals in large cities, suburban lines, branches to main lines and mountainous divisions. The trunk line operation will come later when the electrical systems are further improved.

These remarks, however, do not apply to the conditions as we find them on the Pacific Coast. Here we have available water powers distributed at frequent intervals all the way from Southern California up into British Columbia. Only a very small portion of the water powers have been developed, but even with the stations now operating, and the present transmission systems carrying power throughout the central portion of the State, we have conditions which would seem to make profitable the operation of at least some of the railroads by electricity.

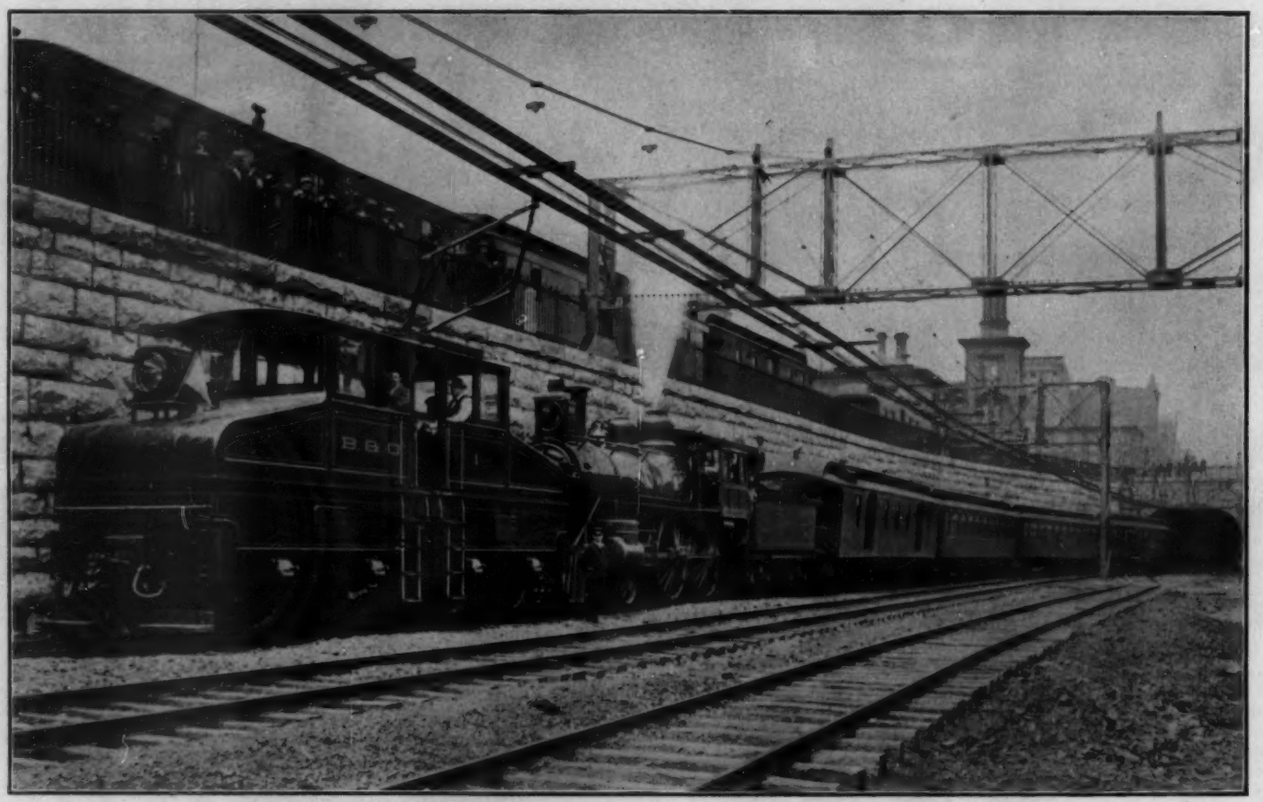


FIGURE 8. ELECTRIC LOCOMOTIVE HAULING TRAIN OF CARS, BALTIMORE AND OHIO TUNNEL, BALTIMORE MD.

It is obvious that an important advantage in the centralization of producing the power results from the fact that the capacity of the steam locomotive has to be that of the maximum effort required from it even though that effort be for a very short time only, whereas, the load on the power station is only the sum of the loads on the different motors which will average much less than the sum of their maximum powers.

This materially reduces the cost of operating, especially with the conditions as we have them on the Pacific Coast, where several power plants can feed into one network and supplement the power of each other.

That the same power may be used for the operation of trains as well as for the operation of shops and the lighting of offices and depots is a self-evident advantage.

A further advantage of the centralization of power is the possibility of recovering energy lost in braking. This plan is followed successfully on several railways in Europe, and examples are on record where from 55 per cent. to 60 per cent. of power is recovered. A notable example of such a railway is that operating on the Jungfrau electric road in Switzerland. The energy which is developed by the descent of the train is transformed to electric energy, since the motors work as generators, thus eliminating to a great extent the necessity for brake action and the resulting wear on the wheels and rails from the brake shoes and slippage. The current which is thus produced returns to the central station by the conductors.

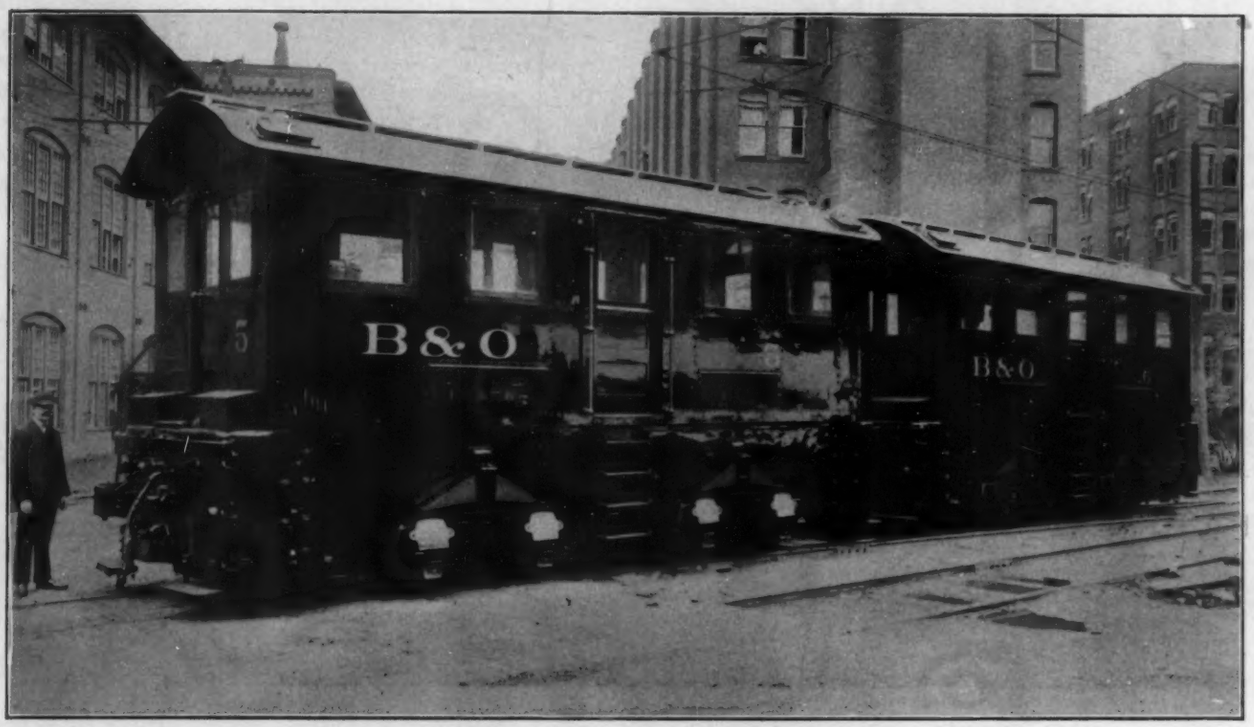


FIGURE 4. A 160-TON LOCOMOTIVE, CONSISTING OF TWO UNITS, FOR THE BALTIMORE AND OHIO RAILROAD

In such a system of distribution as is possible in California, what power might be generated by trains descending a mountain division could be fed back into the distribution lines and thus be utilized. It is probable that on future railways there will be greater development in this direction than we have seen in the past.

The cost of roadbed construction is in favor of electricity in some items, particularly because the limiting grade is higher on the electric railroad. This not only often permits a shorter route, but reduces the necessary excavations and fills. This item may not be of so much importance when considering the changing of motive power of existing steam railroads, but it has an important value in considering possible extensions and feeders to existing lines, especially in mountainous districts. On the other hand, the cost of right-of-way, stations, signaling systems, etc., will be practically the same on railroads operated either by steam or electricity. The claim has been frequently made that roadbeds and tracks can be made lighter and at less expense for an electrically operated system than for a steam road, due to the lighter maximum wheel weights and the lack of pounding, as there are no reciprocating parts as with steam locomotives. This, however, has been questioned. With electric operation the speeds in service are generally increased, and consequently the tracks and roadbeds should be quite as heavy as formerly. However, the higher rotative speeds which are readily obtained with electric motors make it possible to use smaller wheels, and the absence of unbalanced rotating and reciprocating parts permits these speeds to be attained without serious damage to track or motors. Thus, the weight of the engine or motor is reduced to simply that required to be put on the driving wheels for tractive purposes, while, as has already been mentioned, with the multiple-unit system the locomotive may be done away with entirely and the driving done through the wheels and axles of the cars which carry the load. It has been assumed that this will effect a saving of 10 per cent. in the cost and maintenance of track. It will also largely reduce the strain on bridges and trestles and the roadbed in general.

The capacity of the existing railroads may, in certain cases, be increased. For example, on railroads having long tunnels, or at terminal stations where real estate is very expensive, a greater capacity of trains may be secured more cheaply by electrical equipment than otherwise, due to increased average speeds already mentioned, greater ease in switching at terminals, and the use of more powerful locomotives. This last point is a very important one, and contains great future possibilities for the electrically operated

FIGURE 5. IN THE CAB OF ONE OF THE 180-TON BALTIMORE AND OHIO LOCOMOTIVE UNITS

trains. This was illustrated in the Berlin-Zossen experiments, where the equipment of a single car, with a capacity of fifty passengers, was able to develop continuously 1000 horsepower and a maximum of 3000 horsepower. There is a limit to the power which can be obtained from steam locomotives, and recent investigations lead us to believe that we are rapidly approaching, if we have not already reached, that limit. The power of the steam locomotive is limited by the boiler, by the steam pressure which can be efficiently employed, by the amount of coal which can be burned on the limited grate surface in the limited fire box, and there is a limit to the work which the fireman, or even two firemen, can perform in stoking. All of these limits have practically been reached in the modern high powered steam locomotive, and whatever this limit may be in favorable weather, it is again greatly reduced by conditions of extremely cold weather. when the reduced steam capacity of the boiler, the reduced physical strength of the fireman and the bad track surface, all unfavorably affect the production of the increased horsepower needed to maintain schedule speed.

The saving of time and labor in the case of the electric locomotive is an important one. The crew of the steam locomotive devotes a large amount of their time to tending to the fires, getting up steam, shoveling in coal, watching the steam and water gauges and taking on coal and water, time which is saved on an electric locomotive, the labor being performed at the power houses many miles distant, requiring only comparatively few attendants.

The electric locomotive is a machine which is characterized by simplicity and the rapidity with which repairs can be made on the motor. The cost of maintenance is also considerably less than that of the steam locomotive. It has been estimated than in trains weighing 250 tons, the cost of repairs per 100 ton-miles is 25 cents for steam locomotives and 8 cents for the electric locomotive. There is also reason for the claim that the maintenance of the cars would be less on an electric road. It also has been estimated that the number of break-downs would be lessened by half, and as from 6 to 8 per cent. of the detentions on steam roads are probably due to locomotive failures, the substitution of the electric motor would save 3 to 4 per cent. of the time now lost.

As regards relative reliability, the steam locomotive may seem to have an advantage by reason of its being a self-contained unit. On the other hand, there is much less danger of a complete break down of electric motors than of steam locomotives, and with a properly designed and constructed distribution system the probability of a total break-down is ex-

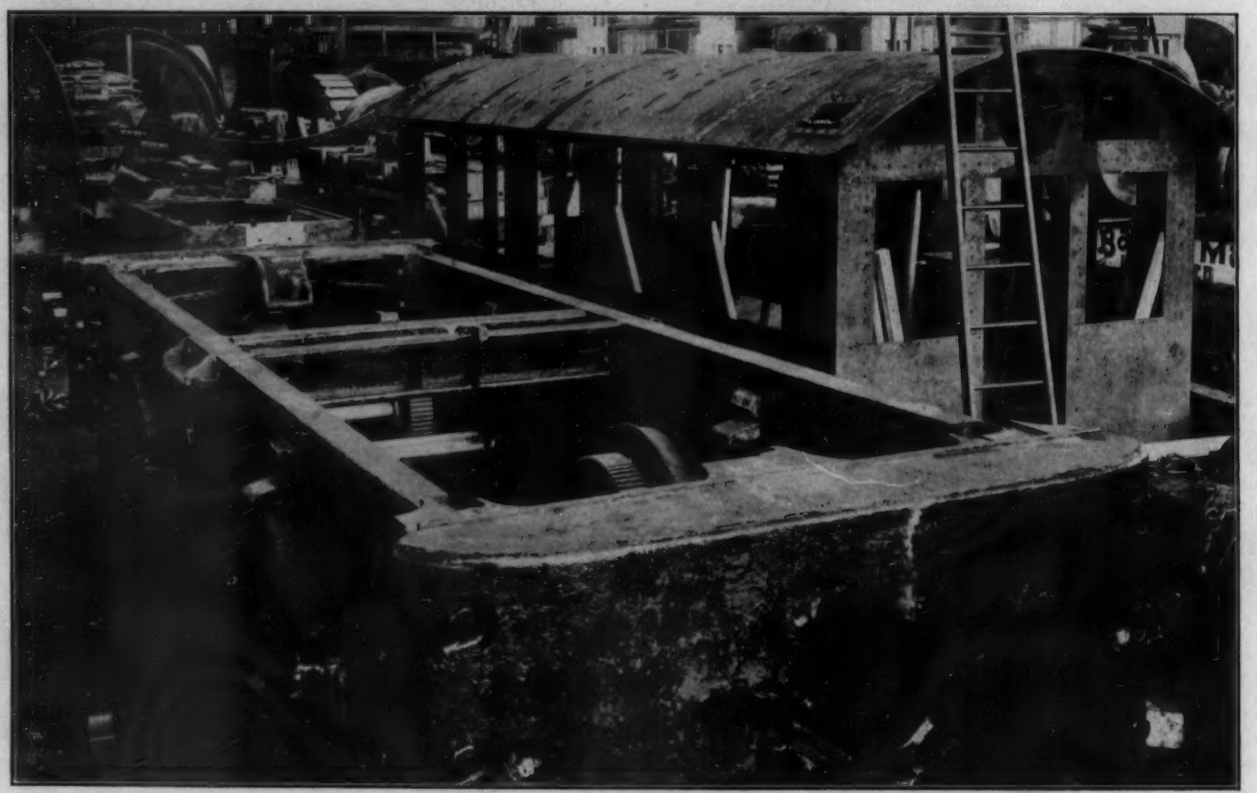


FIGURE 6. TRUCK AND FRAME CAB OF BALTIMORE AND OHIO ELECTRIC LOCOMOTIVE

tremely remote. Considering all the factors entering into the case, especially with reference to the local conditions in Cali-

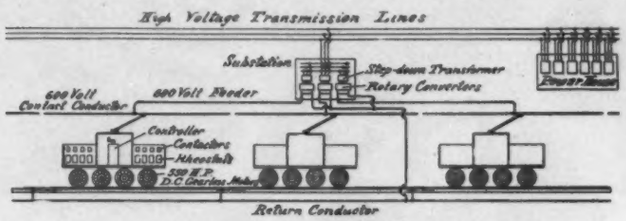


FIGURE 7. DIAGRAM OF ELECTRICAL TRANSMISSION AND DISTRIBUTION OF NEW YORK CENTRAL SYSTEM

fornia, we feel justified in saying that electricity already is fully as reliable as steam.

With the same signaling appliances and conditions of operation the safety of rain operation by steam or electric systems should be the same, except in special cases, such as tunnel or underground roads where electric operation is unquestionably much safer. It is possible also, with the electric system to increase the safety by automatically controlling the trains by cutting off current if a train runs past its signal. It has been stated that risks from fire are considerably greater with electric than with steam traction, but with the present methods of construction and the use of proper safe guards the risk is no greater, and with the steam locomotive we always have risk from the fire carried.

An item which sooner or later will have to receive serious consideration is the fuel for steam locomotives or for central steam plants operating railroad systems. There is a considerable economy and saving of fuel in the operation of a railroad system from a central steam station under certain conditions, as already outlined, and of course with the probable increase in cost of fuel this advantage will be still greater with the central steam plant than with the steam locomotive by reason of the greater economy possible in the utilization of heat derived from this fuel. This emphasizes the great advantages of using the water powers with nature perpetually supplying the necessary energy at no expense beyond its mere control and conversion.

Another point that should be considered is that steam locomotives, when idle, as at stations, sidings and terminals, and when coasting, continue to consume fuel. This does not apply to electric locomotives, and as has already been mentioned when descending grades power may be fed back into the line, the motors acting as electrical brakes and becoming generators of power.

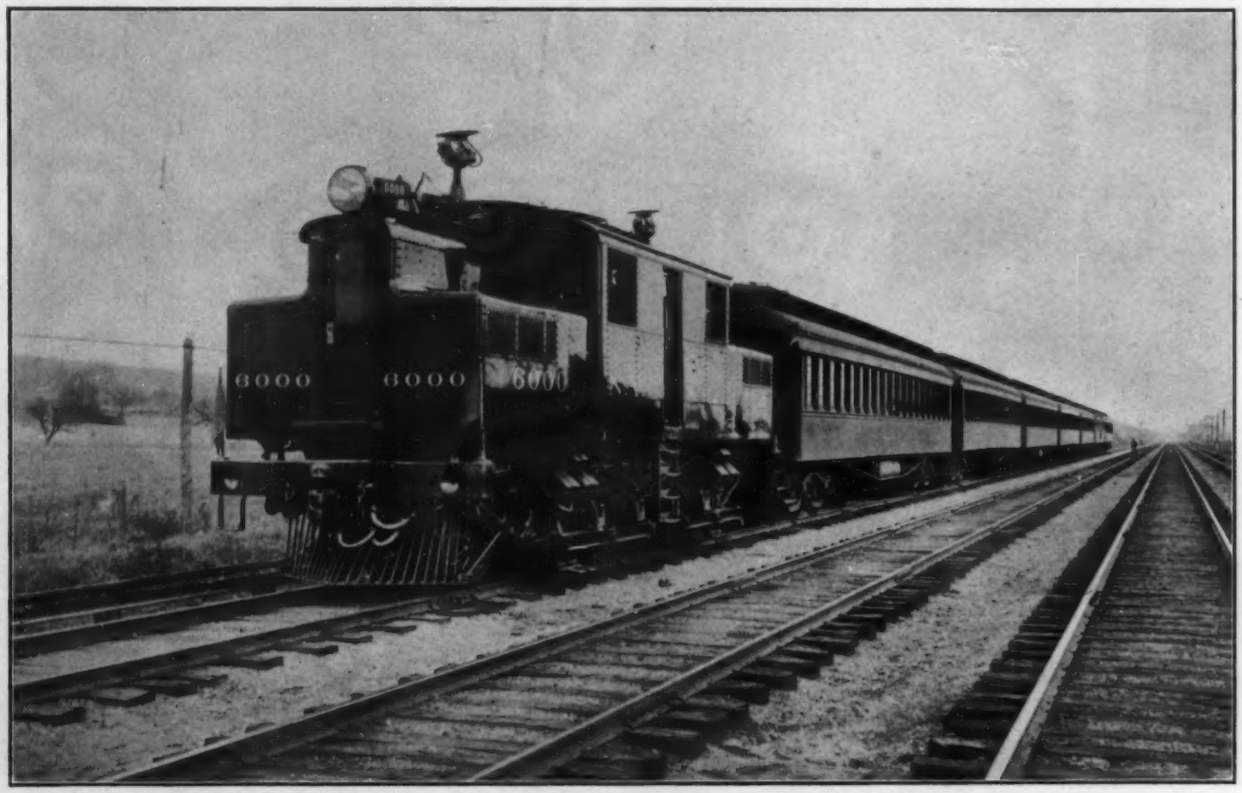


FIGURE 8. NEW YORK CENTRAL ELECTRIC LOCOMOTIVE AND TRAIN

Before entering upon a discussion of what has already been accomplished in electric traction and of its possibilities on established railroad systems, we will refer briefly to some of the steam locomotives which may be considered as types of the best construction and practice of the day.

Four locomotives were recently built for the Southern Pacific Company by the Schenectady Works of the American Locomotive Company. All use oil for fuel except the Pacific type.

The Consolidation type weighs 203,500 pounds in working order, with 181,000 pounds on the drivers, and has a maximum tractive effort of about 43,300 pounds. The engine and tender weigh 338,600 pounds. The tender carries 7000 gallons of water and 2940 gallons of oil.

The Pacific type weighs 214,000 pounds in working order, with 133,000 pounds on the drivers, and has a maximum

NOTE—Indebtedness is acknowledged to the *Electrical World and Engineer* Figures 7 and 14.

tractive effort of about 29,900 pounds. The engine and tender weigh 347,600 pounds. The tender carries 7000 gallons of water and fourteen tons of coal.

The Atlantic type weighs 186,500 pounds in working order, with 97,500 pounds on the drivers, and has a maximum tractive effort of about 23,500 pounds. The engine and tender weigh 321,620 pounds. The tender carries 7000 gallons of water and 2940 gallons of oil.

The switching engine weighs 147,000 pounds in working order, and has a maximum tractive effort of about 27,900 pounds. The engine and tender weigh 227,060 pounds. The tender carries 4000 gallons of water and 1020 gallons of oil.

In view of the attention which the New York Central and Hudson River Railroad Company is paying to electric traction it is interesting to note a New York Central passenger four-cylinder balanced compound locomotive of the 3000 type. This locomotive weighs in working order 200,000 pounds, with 110,000 pounds on the driving wheels, and has a maximum tractive effort of 27,500 pounds or only 9 per cent. of the total weight of engine and tender, which is 321,600 pounds.

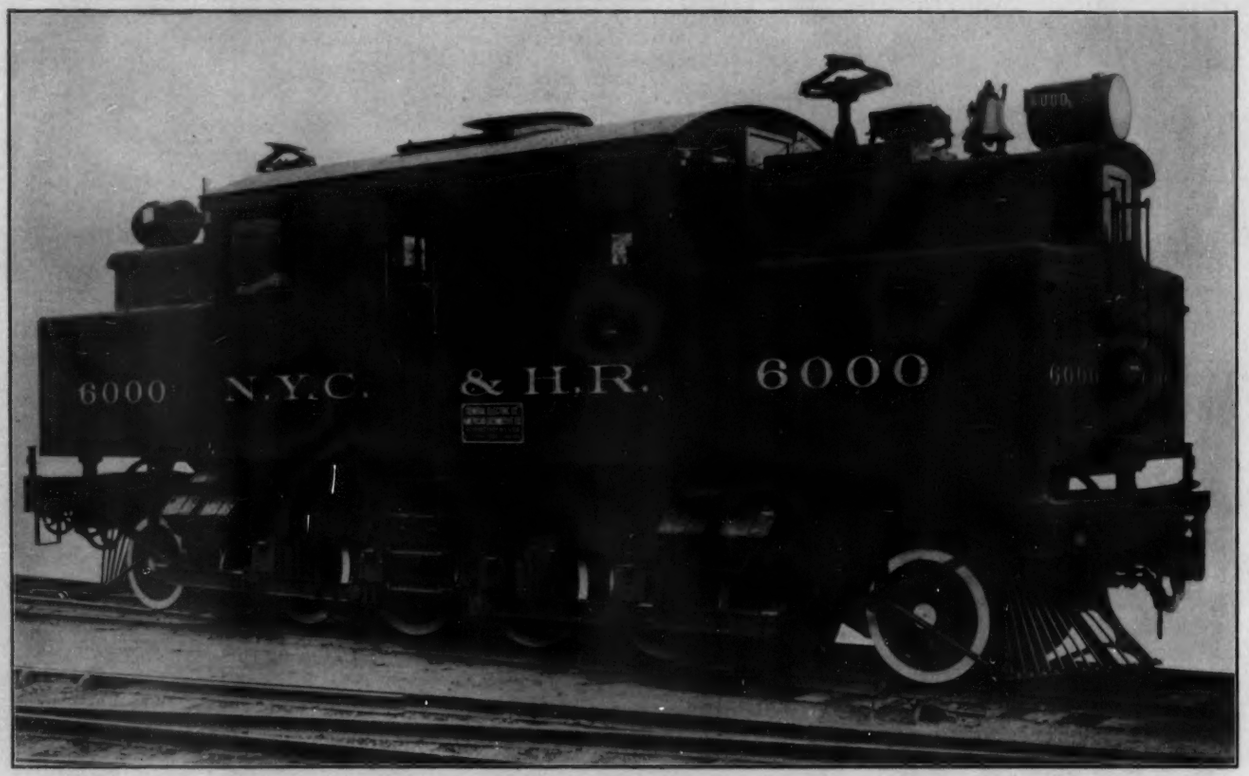


FIGURE 9. NEW YORK CENTRAL LOCOMOTIVE

It also is interesting to note the Mallet articulated compound which is used for hauling freight on the Baltimore and Ohio Railroad and is said to be the largest and most powerful steam locomotive in the world. It has practically a common source of energy; that is, one boiler and a single control for the two locomotives, each of which has six driving wheels for the rigid wheel base, the forward engine with its two cylinders, drivers and steam pipes, being articulated, relative to the frame, boiler and rear engine which are rigidly connected together. The total weight of the engine in working order is 334,500 pounds, all of which is on the driving wheels, and the normal tractive effort when running compound is about 70,000 pounds, but by working the engine simple, this can be increased to 85,000 pounds. With the tender, the total weight is 473,800 pounds, or nearly 237 tons.

The development of electric traction in the United States, as well as in other countries, has been a remarkable one. Beginning about twenty years ago, it has grown until now it embraces in the United States a total of about 35,000 miles and the capital liabilities of the operating companies amount to considerably over three billion dollars.

A good idea of the remarkable and rapid growth of the electric railway may be obtained by comparing the statistics of the years 1890 and 1902 for both steam and electric traction. In this period of twelve years the mileage of steam roads increased only 25 per cent., reaching a total of 202,000, while the electric roads increased over 1900 per cent., reaching a total of 24,330 miles. These figures may be taken as indicative of the relative growing importance of the electric operation of railways.

As already mentioned, the steam locomotive appears to be fast approaching limiting facts in its construction, while on the other hand the electric locomotive, deriving its power from central sources, seems but to have entered upon its growth and posibilities.

The electric railway, as we generally think of it to-day, is the familiar trolley car operating in all the cities of the United States.

In February, 1904, there were in operation in Ohio 2917 miles of road. Many of the lines then under construction and projected have since been completed so that now it is safe to say that there are 3500 miles of electric roads in operation. These roads include two third-rail lines, one of which has

been designed for handling heavy freight and will open up extensive coal fields.

By means of lines now operating passengers can travel by electric car between Columbus and Cincinnati and Indianapolis and sleeping cars are soon to be operated between those points. A recent special trip was made over electric railways in Ohio and Indiana consuming three days and covering 782 miles, the actual running time being twenty-seven hours and fifteen minutes. It is now possible to travel on electric cars from Erie, Pa., through Cleveland, Toledo and Detroit to Kalamazoo, Michigan, a distance of 400 miles. Roads under construction will soon give conection from Buffalo to Chicago closely paralleling the steam line of the Lake Shore & Michigan Southern Railway. The completion of short links will also connect Toledo and Cleveland with Cincinnati and the latter city with Wheeling, West Virginia. Ohio already has a network of railroads electrically operated which rivals, if not surpasses, any section of steam lines in the country.

In this connection it is interesting to note that regular through electric service is now given between New York and Philadelphia and that it is also possible to travel by electric cars between New York City and Boston. With the completion of a few miles of line, passengers will also soon be able to ride in electric cars from Albany to Buffalo and then through to Chicago and Milwaukee.

It seems evident that electric traction will develop even more rapidly in the near future than it has in the recent past, and undoubtedly the Pacific Coast will have a prominent part in this work.

Within the last three or four years the interurban railroad has taken fast hold upon the country, and with improved methods of construction and of power generation and distribution we have seen it develop until it is now a well established factor in the progress of civilization. Already it is approaching and in many sections exceeds the city lines in aggregate mileage.

California has some 1500 miles of street railways, most of which are operated electrically. Of this total practically 1000 miles may be classed as interurban roads, either connecting adjacent cities or linking suburban towns and resident communities to the larger cities.

It is but a step from the fast modern interurban car, as we have it in Los Angeles, San Jose, Santa Rosa and other points in the State, to the interurban trains operating under steam railroad conditions, such as the North Shore and Key Route systems.

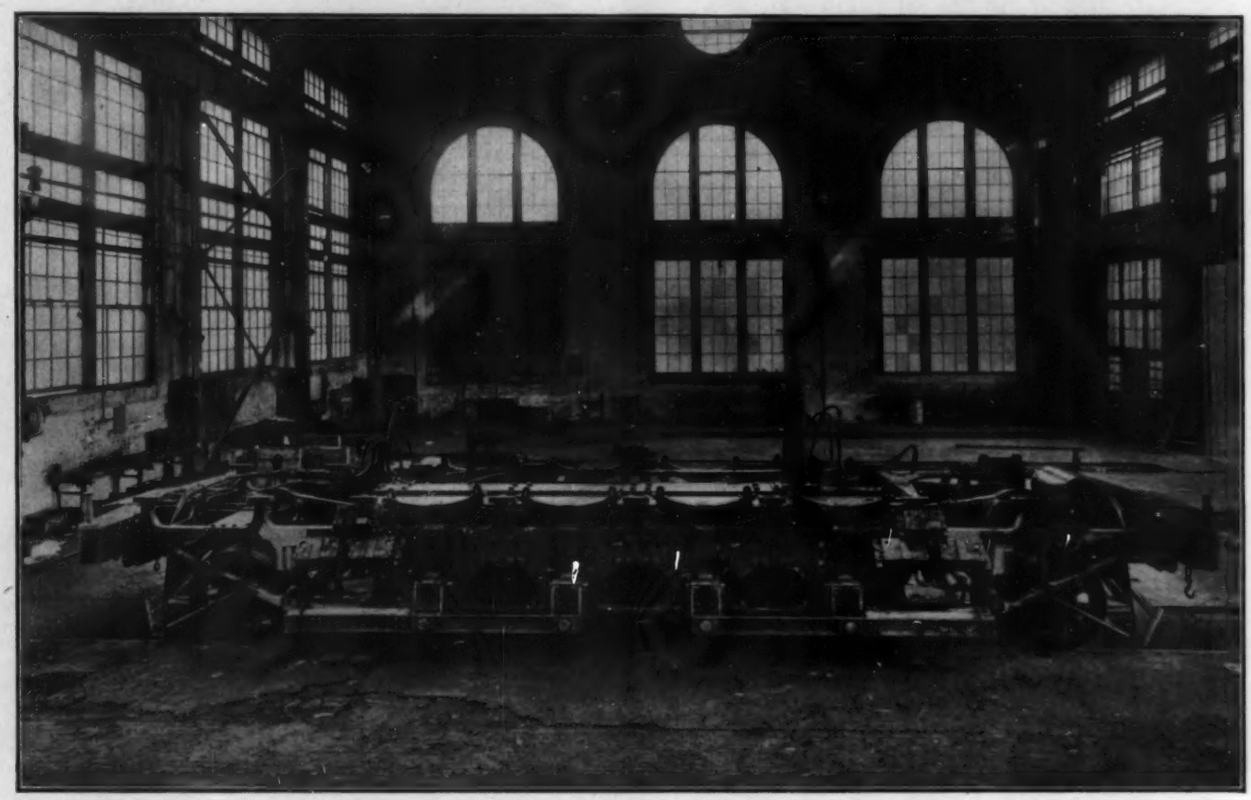


FIGURE 10. NEW YORK CENTRAL ELECTRIC LOCOMOTIVE AND RUNNING GEAR

Again it is but another step to the electric locomotive, which seems to be necessitated in some instances by local conditions. Mention and illustration will now be made of some of the more interesting types of electric railway features, beginning with the direct current locomotives and following with systems employing alternating current.

The electric locomotive for general freight or passenger service has come into use in a number of places in the United States where the conditions either demanded it or made it commercially possible. One of the first was built in 1894 by the General Electric Company, and was known as the Cayadutta locomotive. It weighs thirty-five tons and is equipped

with four 125 horsepower motors, mounted one upon each axle of two four-wheeled bogie trucks through single-reduction gearing. It is operated by direct current, equipped with two trolleys, and is now doing freight service at Taftville, Connecticut.

The electric locomotive shown (Figure 1) is one of two thirty-six-ton locomotives used by the Buffalo and Lockport Railway. It has a steeple cab with sloping ends and is mounted on two swiveled bogie trucks, having swing bolsters supported by elliptical springs, the truck proper resting on coil springs which are in turn supported by equalizer bars. At 300 horsepower, which is the nominal rating of the locomotive, it will accelerate a 450-ton train to fourteen miles per hour on level track.

An electric locomotive operating between the North German Lloyd piers at Hoboken, N. J., and the Erie tracks in Weehawken, a distance of about two miles, is equipped with four 140 horsepower motors and has a draw-bar pull at eight miles per hour of 10,000 pounds.

A locomotive operating on the St. Louis and Belleville Suburban Railway in Illinois is similar in mechanical construction to the Buffalo and Lockport locomotives, and is equipped with four 150 horsepower motors. It weighs fifty tons, is designed to draw a trailing load of 675 tons at a speed of about ten miles per hour on level track and gives a tractive effort of 17,100 pounds.

A statement by an officer of the St. Louis and Belleville Electric Railway Company referring to the operation of this locomotive is of interest. He says:

"The average mileage performed per day by the engine which does the road work is sixty miles.

"The engine is working almost every day of the year, except Sundays and holidays, averaging about 312 days a year, and averaging ten hours per day work.

"We have a standard railroad equipment of 400 coal cars of 80,000 pounds capacity, and hauled last year more than 300,000 tons of coal and miscellaneous freight. Our train loads average about 720 tons, or eighteen cars.

"The train crew consists of the standard railroad requirements of four men, which are the engineer, the foreman, trolley man (who acts as front-end switchman), and hind-end switchman. The wages paid are 29 cents per hour for the foreman and 27 cents per hour for the others.

"The records show that for the past year the repairs to the engine which has performed the above work, have been a little over $88.00.

"The other engine of the same type and capacity is employed in shifting cars at and around the power house yards. The repairs to this engine have been considerably lighter than the other engine.

"I might add that this road is an exclusive freight road, and is probably the pioneer electrical freight road in the country."

An electric locomotive recently built (Figure 2) for the Northeastern Railway of England is of interest by reason of its being the largest electric locomotive ever built in England. It is used on the electrified section of the Northwestern Railway, near Newcastle, displacing steam locomotives formerly used for hauling freight trains. It weighs 112,000 pounds, is equipped with four 150 horsepower motors, and is controlled by the multiple-unit system which is also used on the electric passenger trains of this railway. As the locomotives have to operate over sections fitted both with overhead line and third rail, a sliding bow trolley has been provided in addition to the collecting shoes.

Each locomotive is capable of handling a 300 gross-ton train on the level at a speed of fourteen miles per hour and of starting with a train of 150 tons on a grade of 1 in 27 under all conditions of weather, running up this grade at a speed of nine to ten miles per hour.

One of the first steam roads to substitute electricity for steam on a portion of its trunk line was the Baltimore and Ohio Railroad Company in the equipment of the Baltimore Belt Line Tunnel. The General Electric Company furnished, in 1896, for the operation of freight and passenger trains through this tunnel, three ninety-six-ton electric locomotives, each equipped with four six-pole gearless type, 360 horsepower motors, the armatures being spring-suspended upon a quill surrounding the axle and the field being spring-supported upon the frame. Figure 3 shows one of these locomotives hauling the "Royal Blue" train.

These locomotives proved satisfactory and even more than met the most sanguine expectations, leading to the placing of an order for two larger ones which were built in 1903 and are now in commercial service. They are among the most powerful in the world, and owing to their size it was considered best to build them in two separate units (Figure 4) of eighty tons each. The cab is of the box type and gives ample space (Figure 5) for the accommodation of the apparatus of the Sprague-General Electric control system. Glass doors and windows furnish an unobstructed view of the track and surroundings in all directions.

The main body of the truck frame (Figure 6) is built up of four heavy steel castings, the parts being machined at the ends and securely fitted and bolted together, thus forming a strong and rigid structure capable of withstanding severe shocks without injury. The end pieces form the buffer beams, and to these is attached a draft gear of approved design which will withstand a maximum draw-bar pull of approximately 100,000 pounds. The principle dimensions of the locomotive are as follows: Weight of locomotive, one hundred and sixty tons, (eighty tons per unit); number of units, two; horsepower rating of each motor, two hundred horsepower; number of motors (four per unit), eight; total tractive effort for two units at full load on motors, 70,000 pounds.

In order to convey some idea of the relative size of these locomotives it may be noted that at the nominal rating of the motors each locomotive is capable of accelerating on a level a train weighing 3000 tons to a speed of thirteen miles per hour. The locomotive will accelerate a 1400-ton train to a speed of ten miles per hour on a 1 per cent. grade. The free running speed of the locomotive, without train, is approximately twenty-four miles per hour.

Following the precedent set by the Baltimore and Ohio Railroad and some of the other large steam roads, the Philadelphia and Reading Railroad is preparing for the handling of freight traffic upon an extensive scale by electric locomotives upon its Cape May, Delaware Bay and Sewell's Point Branch. This branch is a seven-mile electrically operated line, extending from Cape May to Sewell's Point, formerly operated mainly for passenger service; now freight also will

be handled from both the Philadelphia and Reading and the Pennsylvania Railroad to this newly developed portion of Cape May.

The most important electric railway tests ever made in the United States were conducted with notable success last November by the New York Central and Hudson River Railroad Company, when the new high speed electric locomotive built jointly by the General Electric Company and the American Locomotive Company, was given its first public trial. That these preliminary tests were a distinct success presages a brilliant future for the electric locomotive.

This road is now electrically equipping its New York terminal for a distance of thirty-four miles on the main line from the Grand Central station to Croton and for twenty-four miles on the Harlem Division as far as White Plains.

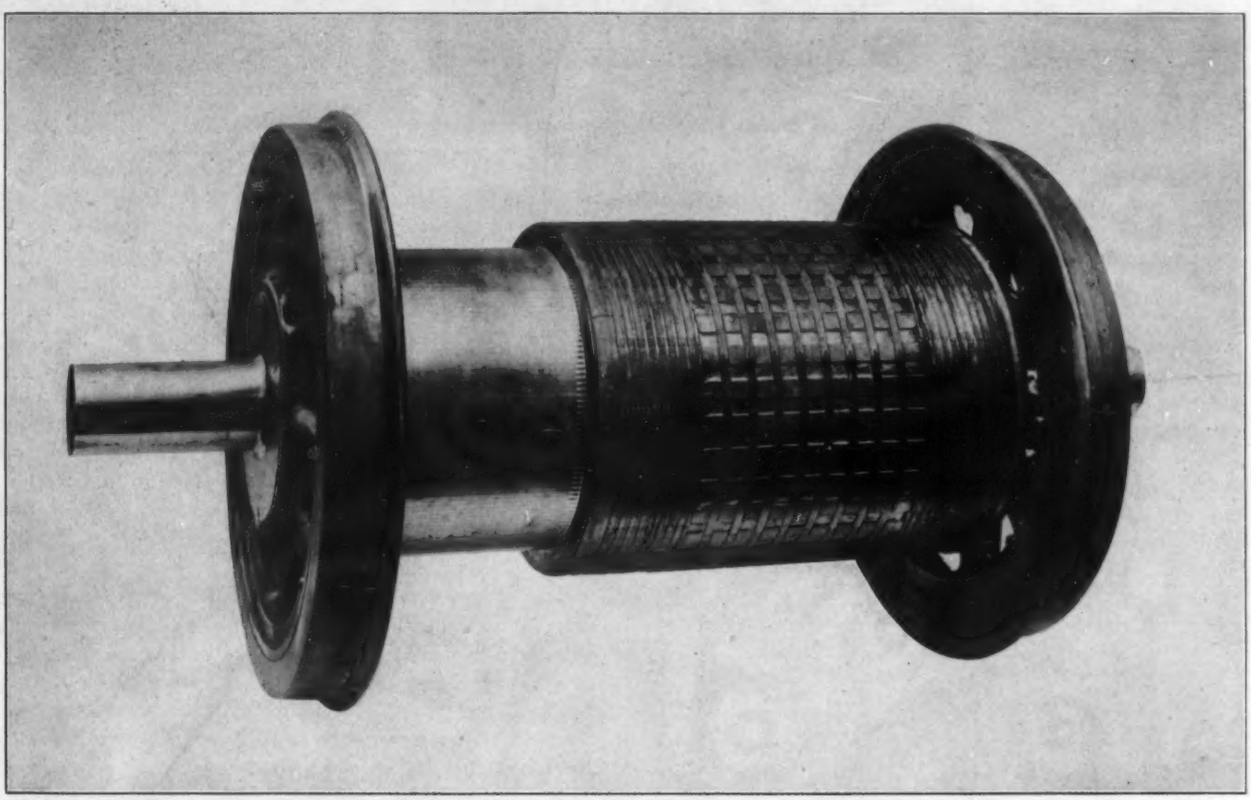


FIGURE 11. NEW YORK CENTRAL ELECTRIC LOCOMOTIVE ARMATURE, AXLE AND WHEELS

It is the intention to handle all the traffic over these divisions electrically, and the locomotive just given trial is one of thirty to fifty which will be used in the haulage of the through passenger trains, the heaviest of which reach 875 tons in weight and are to be hauled at a maximum speed of sixty to sixty-five miles per hour.

The diagramatic sketch (Figure 7) shows the electrical system of transmission and distribution which will be used. It consists briefly of a three-phase alternating current high voltage transmission line from the main power house to several substations located at convenient points. In these substations will be installed step-down transformers and rotary converters which will feed into the distribution system 600-volt direct current.

Two or more locomotives can be coupled together and operated from the leading cab as a single unit. A single electric locomotive will be able to maintain the schedule with a 450-ton train, two locomotives being coupled together for heavier trains.

The locomotive which is shown in Figure 8 with a standard train, developed remarkably easy riding qualities at high speeds and during acceleration, responding with ease and power to the will of the operator.

The designers have secured in this machine the best mechanical features of the high speed steam locomotive combined with the enormous power and simplicity in control made possible by the use of the electric drive. The success of the trials forcibly demonstrated that the steam locomotive has encountered a most formidable rival in a field of which it has heretofore held undisputed possession, and it is the general opinion that in the new locomotive has been found a type whose distinctive features may be accepted as a basis for future standardization.

The locomotive shown in detail in Figure 9 consists of four driving axles on each of which is mounted, without intermediate gearing, the armature of an electric motor having a normal rating of 550 horsepower. The total rated capacity of the locomotive is 2200 horsepower, although for short periods a considerably greater power may be developed, making it more powerful than the largest steam locomotive in existence.

Figure 10 shows the locomotive frame and running gear partly assembled. Hitherto gearless locomotives have been built with the armature of the electric motors mounted on quills and spring-suspended from the driving wheels. In the new locomotive the use of spring-suspended quills is dispensed with, the armature being mounted rigidly upon the

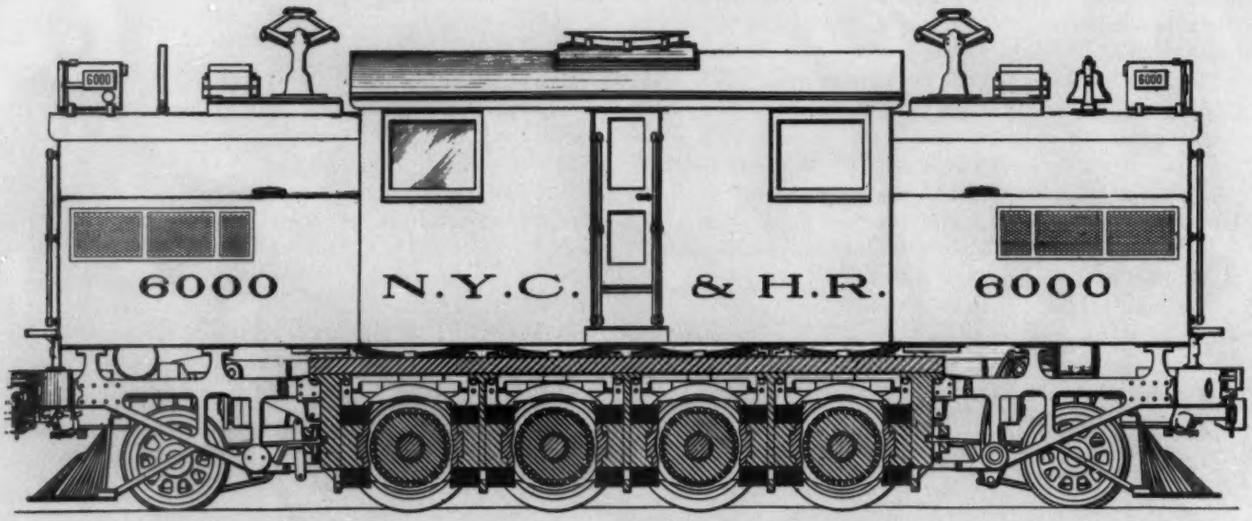


FIGURE 12. NEW YORK CENTRAL ELECTRIC LOCOMOTIVE, LONGITUDINAL SECTION THROUGH FRAME

axle (Figure 11) thus reducing the bearings to those of the pony trucks and the main journals, all of which are outside of the driving wheels. The motor has two poles with flat faces so as to permit a large relative vertical movement between armature and poles as the latter move up and down with the riding of the frame upon the springs.

A longitudinal section of the locomotive frame is shown in Figure 12. The main frame is of cast steel and forms not only the mechanical frame of the locomotive but also part of the magnetic circuit of the electric motors. It will be seen that the armatures are arranged in tandem, the end pole pieces being cast as part of the end frames and the double pole pieces between the armatures being carried by heavy transoms bolted to the side frame and forming part of the magnetic circuit as well as cross braces for the truck. The field coils are wound upon metal spools which are bolted upon the pole pieces. Proper distribution and division of the weight of the locomotive among the axles has been accomplished by suspending the main frame and superstructure from a system of half elliptic springs and equalized levers of forged steel, the whole being so arranged as to cross-equalize the load and to furnish three points of support.

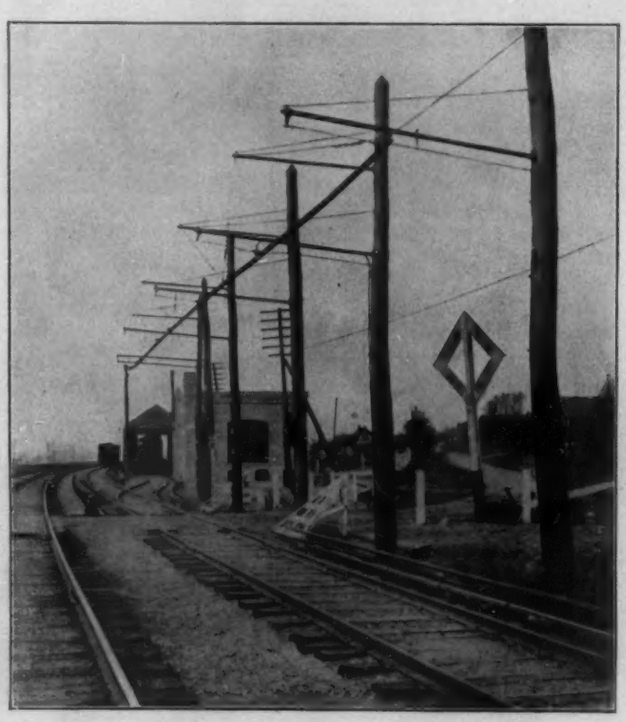


FIGURE 13. NEW YORK CENTRAL TEST TRACK

This construction, besides being strong and simple in design, greatly facilitates repairs and renewals as an armature with its wheels and axle may be removed by lowering the complete element without disturbing the fields or any other part of the locomotive and a new element inserted in its place. All parts are also especially accessible for inspection and cleaning.

The pony trucks are of the radial type and are pivoted by means of radius bars to the end frame of the main truck. The frame of the locomotive immediately above the trucks is supported by means of suitable links so that the truck is free to swing about its center and is self-centering on a straight track. This design is similar to the standard construction adopted by the New York Central and Hudson River Railroad Company for its steam locomotives.

The brush holders are mounted on insulated supports attached to the spring saddle over the axle journal, thus maintaining a fixed position of the brush holder in relation to the commutator. These brush holders are made adjustable so as to allow for wear of the commutator and journal bearings.

The dead weight on the axle is not materially greater than is customary with steam locomotives, and in addition there is no unbalanced weight to produce vibration with attendant injuries to track and roadbed construction. The actual reduction in the expense of maintaining the rails and roadbed, due to the absence of pounding and rolling, will have an important bearing on the up-keep of the permanent way.

The superstructure consists of a central cab for the operator containing master controllers, engineer's valves, and switches and valves required for operating sanding, whistling, and bell ringing devices. This apparatus is furnished in duplicate, one set on each side of the cab, and is arranged so as to be easily manipulated from the operator's seat, while at the same time a practically unobstructed view to front and rear may be obtained from the windows.

There is a central corridor extending through the cab so to permit access from the locomotive to the cars behind, and the contactors, rheostats and reversers are arranged along the sides of these corridors in boxes of sheet steel which are sheathed on the inside with fireproof insulating material. All of these appliances are therefore easily accessible for repairs or inspection.

The control system permits three running connections, namely, four motors in series, two groups of two in parallel series and all four motors in parallel.

Current is collected from the third rail by multiple contact spring-actuated third-rail shoes whose supports are carried

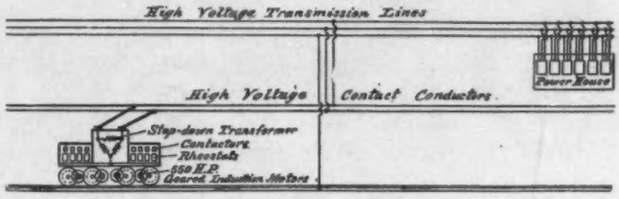


FIGURE 14. DIAGRAM OF ELECTRICAL TRANSMISSION AND DISTRIBUTION OF THREE-PHASE SYSTEM

on channel irons attached to the journal box. There are four of these shoes on each side of the locomotive. In the yards at the terminal the large number of switches and crossings necessitates an overhead construction in places and additional contacts are therefore mounted on the top of the locomotive for collecting current when the locomotive is passing over these points. This device may be raised and lowered by air pressure controlled from the engineer's cab. A magnetic ribbon fuse is placed in circuit with each shoe and overhead contact device so as to secure protection in case of accidental short circuit.

It is the intention to make complete tests and trials on these locomotives under all conditions in service operation. For this purpose a six-mile stretch of track (Figure 13) on its main line near Schenectady has been equipped with standard third-rail construction. The track is practically straight and ballasted so as to permit maximum speeds of seventy to eighty miles per hour being attained.

The general dimensions and data applying to the locomotive are as follows:

Number of driving wheels, eight; number of pony trucks, two; total weight of locomotive, ninety-five tons; weight on drivers, sixty-nine tons; diameter of drivers, fourty-four inches; diameter of pony truck wheels, thirty-six inches; diameter of driving axles, eight and five-tenths inches; normal rated horsepower of locomotive, 2200; maximum horsepower, 3000; normal draw-bar pull, 20,400 pounds; maximum starting draw-bar pull, 32,000 pounds; speed with 500-ton train, sixty miles per hour; rating of each motor, 550 horsepower.

In the preliminary tests an eight-car train weighing 336 tons and a four-car train weighing 170 tons, both exclusive of locomotive, were used. The total weight of train, including locomotive and passengers, was 431 tons and 265 tons, respectively.

The maximum speeds reached were sixty-three miles per hour with an eight-car train, and seventy-two miles per hour with a four-car train. The trains were still accelerating at these speeds, but the length of track so far equipped did not permit attaining high speeds.

The New York Central locomotives are not designed for abnormally high speeds at intervals, but rather to obtain a high average schedule, due to their ability to accelerate more rapidly than is possible with the present steam locomotives.

In the accelerating tests a speed of thirty miles per hour was reached in sixty seconds with the eight-car train, corresponding to an acceleration of one-half mile per hour per second. During certain periods of the acceleration the increase in speed amounted to six-tenths mile per hour per second, calling for a tractive effort of approximately 27,000 pounds developed at the rim of the locomotive drivers. This value was somewhat exceeded with the four-car train, where a momentary tractive effort of 31,000 pounds was developed at the drivers, with a coefficient of traction of 22.5 per cent. of weight on drivers. The average rate of acceleration with the four-car train weighing, including the locomotive, 265 tons, was thirty miles in thirty-seven and one-half seconds, or 0.8 mile per hour per second, calling for an average tractive effort of 22,000 pounds.

Throughout both the starting and running tests the electric locomotive showed its remarkable steadiness in running, a distinct contrast in this respect to the steam locomotive, especially should the latter be forced to perform the work here shown to be accomplished by the electric locomotive.

The simple construction and high efficiency made possible with this design of gearless motor, together with the minimum cost of repairs attending such a design make it a distinct forward step in electric locomotive construction.

Compared with existing steam practice, it is interesting to note that the heaviest "Atlantic" type locomotive of the New York Central Company weighs approximately 150 tons,

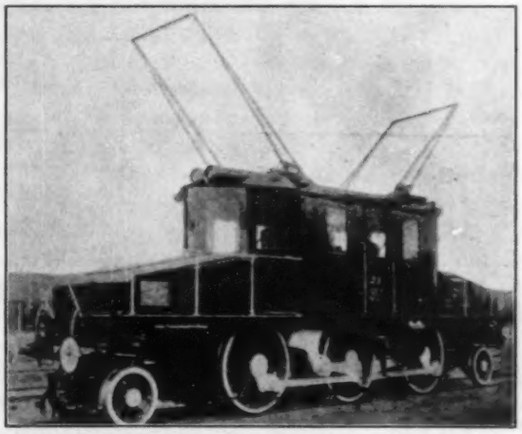


FIGURE 15. LATEST TYPE OF THREE-PHASE VALTELLINA ELECTRIC LOCOMOTIVE

including the tender, of which but forty-seven tons are on two pairs of drivers. It will, therefore, be seen that for every pound of effective draw-bar pull the steam locomotive has a weight of over twelve pounds, as compared with but six pounds with the electric locomotive. Therefore, in a single electric unit, over 25 per cent. greater weight is available for traction than with the largest steam passenger locomotive now in use, with thirty-seven per cent. less dead weight and with twenty-eight per cent. less weight on each axle. Moreover, the electric locomotive will, of course, have an entire absence of counterbalancing of driving wheels and twist from reciprocal motion, both of which in the steam locomotive are so destructive to track and roadbed.

The multiple-unit direct current system is older and has perhaps reached a higher stage of perfection and development than the electric locomotives. Its particular use is found in elevated and underground railways and on interurban systems where traffic conditions approach those of steam suburban lines rather than of the ordinary trolley car. Interesting examples of the use of the multiple-unit method of operation are the elevated railroad systems in Chicago, the Brooklyn and the Manhattan Railways of New York City, the New York Subway, the Boston Railway, the Aurora-Elgin Railway, the Wilkesbarre system and our own

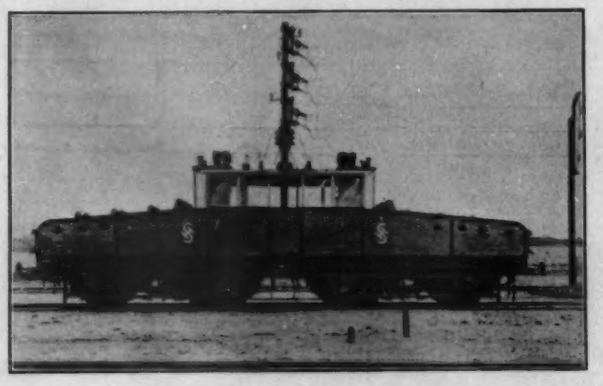


FIGURE 16. SIEMENS & HALSKE ELECTRIC LOCOMOTIVE USED IN BERLIN-ZOSSEN HIGH SPEED TRIALS

Key Route and North Shore Railroads. The system has a great many advantages for operation on suburban lines where the traffic conditions are such that the length of trains has to be quickly changed from hour to hour. As already mentioned there are other important advantages of the multiple-unit system, such as the ability to handle a long train with one motorman, thus reducing the train crew; the increased proportion of the train weight on the driving axles, which in some cases can be made as high as 100 per cent.; the higher average speed which can be maintained, due to the more rapid acceleration of the motors and the more effective braking.

The New York Subway is probably the most modern and up-to-date of all of the multiple-unit systems now operating, and when it is realized that this railway is able to operate trains at intervals of a half minute and is regularly carrying between two and three hundred thousand people a day, one may realize that the details of operation as well as the mechanical features of car and electrical construction have been worked out with considerable care and engineering precision.

In alternating current railway operation there are two particular systems which have received the attention of engineers in this country and abroad, namely, the polyphase or three-phase system and the single-phase system. Although American engineers and railway companies have held aloof from the polyphase methods of operation, claiming that it was not advisable to install it on account of the double overhead conductor necessary, it has on the other hand been extensively exploited in Europe. Some of the most interesting and successful alternating-current railway work has been done in Switzerland, Germany, Austria, Hungary and Italy. On account of the recent attainment of very high speed with polyphase motors on the reconstructed tracks of the Berlin-Zossen line, it is interesting to consider some of the three-phase electric locomotives now in use abroad. The fact that German engineers have been able to travel at the rate of 130 miles an hour on their experimental line, with a good prospect of even exceeding this remarkable speed, certainly indicates the great possibilities of electric power for long distance and high-speed trunk lines.

Figure 14 illustrates diagramatically a type of polyphase system which has been applied in different ways throughout Europe. It consists of a three-phase alternating current high voltage transmission system in conjunction with a high voltage three-phase distribution system and high voltage locomotives which are equipped with three-phase induction motors. This system requires two contact conductors or trolleys, as indicated, the track rails serving as the other side of the three-phase system. Step-down transformers on the car serve to change the high voltage trolley current to voltage suitable for the operation of the motors.

One of the important polyphase systems is that of the Burgdorf-Thun Railway which operates a three-phase mountain road in Switzerland of standard gauge, twenty-five miles in length. The working trolley lines on this railway consists of two copper conductors supplied with current at 750 volts from substations at intervals of two miles along the line. The track is used as one conductor and connects with one terminal at the transformer substations where the current is lowered from 16,000 volts, the pressure at which the power is transmitted from the hydro-electric power house on the Kander River.

The freight locomotive used weights 60,000 pounds, has a capacity of 300 horsepower and is capable of hauling a train of fifty tons at twenty-four and one-half miles per hour up the steepest grade, which is one in forty.

One of the most interesting three-phase railway systems is the Valtellina, in Italy. The contract for this was very

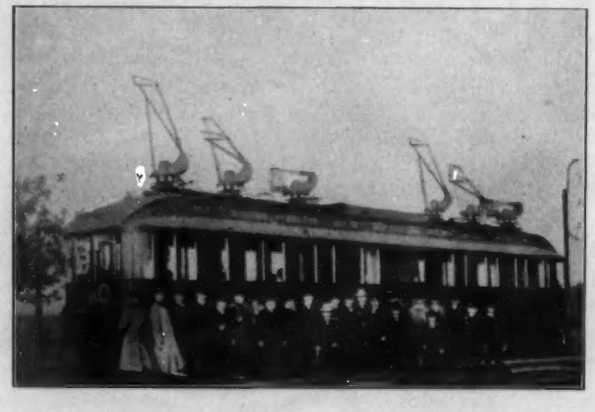


FIGURE 17. ALLEGEMEINE ELECTRIC CAR IMMEDIATELY AFTER THE RECORD RUN

stringent and provided that in case the installation should not prove satisfactory during the first two years' operation the contractor should remove the overhead equipment, transformer stations and electric rolling stock and should only be paid for the value of the central station and high tension transmission line. The entire installation, about sixty-five miles long, was completed early in 1902. The government having by a practical service of one and one-half years found that all the severe conditions had been more than fulfilled ordered acceptance of the entire installation and entered into active negotiations for extending the electric railway.

Power is transmitted to the railway from a water-power plant at 20,000 volts, and is distributed through transformer stations, six miles apart, to the working conductors at 3000 volts, that being the voltage at which the current is taken off by the trolley. The freight trains of 200 tons are handled by electric locomotives, while the passenger service is performed by trains consisting of motor cars and trailers. The locomotives each have a capacity of 600 horsepower and haul trains with ease up grades of ten and even twenty per cent. and around curves of 1000 feet radius.

Recently three new 1600 horsepower locomotives were delivered, one of which is shown in Figure 15.

The trolley device used on this railway consists of two poles with double roller contacts, the two sections of rollers being insulated by a roller of wood. The conductor rollers are of steel, copper plated, and, it is said, will run over 6000 miles before replating becomes necessary. The trolley poles are supported by spiral springs in tension, the tension being put on from within the vehicle by compressed air. This trolley can not run off the wire, as is the case with the wheel trolley, and this accounts for the fact that the overhead construction of the Valtellina line required hardly any repairs during two years of regular service.

The two-wire overhead construction works successfuy at switches, cross-overs and side tracks, and does not interfere in the least with steam locomotive traffic.

A Swiss mountain rack-railway using polyphase locomotives is the "Jungfrau," which is equipped with locomotives having a capacity of 400 horsepower each, and also a number of smaller locomotives of 300 horsepower each. The maximum gradient is 25 per cent., and a speed of nine to ten miles per hour is easily attained.

The high-tension current is conducted by an overhead line twenty miles long from the 2000 horsepower, hydro-electric station at Lauterbrunnen.

The attention of the world has been attracted by the remarkable high-speed experiments which were conducted about a year ago on the specially constructed track between Marionfelde and Zossen, near Berlin. In these trials two types of cars were used, one built by the Allegemeine Elektricitaets Gesellschaft and the other by Siemens & Halske. Each was equipped with four 250 horsepower polyphase motors and current was collected by means of bow trolleys from a three-phase side trolley line at voltages of from 10,000 to 14,000 volts. After several trials the Siemens & Halske locomotive, shown in Figure 16, was finally operated at a speed of 128 miles per hour. A few days later the Allegemeine car was given several trials, the speed being gradually worked up until the remarkable speed of 130 miles an hour was reached. It was stated that at these high speeds both cars ran very steadily. It is interesting to note the effects of such rapid travel. From a car running at such an exceedingly high speed neighboring objects disappear from view almost instantly. Although the motorman can distinguish obstacles on the track, his doing so would be of little use as the distance passed over in bringing the car to a stop from the time of applying the brakes is nearly a mile and a half. It is stated that those watching the car can just distinguish the presence of men in it. Before they were able to recognize them, however, the car had disappeared from view. Although the track is very straight there elapsed at most only one and one-half minutes before the first appearance of the car and its disappearance on the horizon. Figure 17 shows the Allegemeine car taken immediately after the record run. Note the individual trolley collectors, there being one for each wire at each end of the car. The peculiar vane-like shape at the bottom of the trolley was designed to balance the wind pressure. These experiments demonstrate that one of the most difficult problems of electric traction, namely, the transmission of large amounts of energy from a stationary conductor to a train running at enormous speeds has been satisfactorily solved.

It is thought probable that under existing conditions speeds as high as 155 miles per hour may be reached, but proof of this is still forthcoming. The German railway authorities commenced a short time ago a series of trials with steam locomotives, the results of which are interesting in comparison with the performances of electric cars. Speeds as high as eighty-six miles per hour have been obtained, and it seems evident that on account of the heavy weight of the steam locomotive speeds of possibly 100 miles per hour are all that can be hoped for.

(Conclusion in The Journal for April.)

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*On the Economy of Steam Power Plants Using Oil Fuel.**

EXACT calculation of the economy of any given power plant for an assumed set of conditions is almost an impossibility, involving factors not entirely subject to mathematical treatment. But in spite of this fact there are occasions where it is necessary to estimate such economies either for the purpose of making guarantees on prospective plants or to determine how closely any existing plant approaches its maximum possible economy. In either instance it is necessary to study closely the type of units and auxiliaries employed to determine their individual performance either from past records or makers' guarantees, and to deduce the final result sought. The efficiency of a boiler, the steam consumption of an engine, the mechanical losses due to friction, and the electrical efficiency of generators are apparently simple quantities; but to determine the efficiency of auxiliary apparatus by any means other than trial is a problem the solution of which the engineer is loath to attempt, even approximately. The writer feels that he is treading on more or less forbidden ground and lending himself to severe criticism in presenting the series of tables and calculations to follow. It can be stated, however, as a result of numerous comparisons of previously calculated economies and subsequent test determinations, that the errors of the method herein outlined are surprisingly small. In the writer's daily work, it has been necessary to continually resort to such determinations as a basis of making guarantees on proposed plants, adding a percentage for contingencies depending upon the degree of certainty as to the various assumed factors entering into the final results.

In the matter immediately following, calculations refer to maximum economy under duty trial. Falling off in economy due to varying load, stand-by losses, and other conditions of every day service will be explained later.

The discussion of the make-up of plants for the least cost of power will be taken up after the presentation of figures giving economy, first cost, fixed charges, extra supplies, etc., together

*Written for THE JOURNAL by the Engineering Department of Chas. C. Moore & Co., Engineers, Inc.

with a tabulated statement of total cost per kilowatt hour at the switchboard for various sizes and types of plants under various load factors.

ENGINES:

It would be impossible to give a complete tabulation of the economy for various types of engines. The average reader has fairly well in mind the results to be obtained from any given class of machinery, or when contemplating any particular installation is able to obtain exact guarantees from the manufacturer. Large compound condensing engines will now develop an indicated horsepower-hour on 12.5 pounds of saturated steam and 11.5 pounds when superheated to 100 degrees F.

With medium speed engines built after the Manhattan four-cylinder arrangement with direct connected fly wheel type alternators, the total mechanical and electrical losses within the unit have been gotten down as low as 7½ per cent. of the rated horsepower of the engine.

BOILERS:

The problem of boiler efficiency is much simplified owing to the almost uniform calorific value of crude oil used for fuel purposes. The heat value ranges ordinarily from 18,500 to 18,850 British thermal units per pound of oil. The accompanying table, No. 1, gives various calculations based on both of the above calorific values for boiler efficiencies ranging from 70 to 100 per cent. The

TABLE NO. 1—EVAPORATION FOR OIL FUEL FOR DIFFERENT BOILER EFFICIENCIES.

CHAS. C. MOORE & CO., ENGINEERS (INC.), SAN FRANCISCO, CAL.

Efficiency of Boiler Per Cent.	18,500 British Thermal Units Per Pound of Oil.				18,850 British Thermal Units Per Pound of Oil.			
	Pounds Steam Per Pound Oil From and at 212°	Pounds Oil Per Pound Steam From and at 212°	Pounds Steam Per Barrel Oil From and at 212° 336 Pounds Per Barrel.	Barrels Oil Per Hour Per Boiler Horse-power.	Pounds Steam Per Pound Oil From and at 212°	Pounds Oil Per Pound Steam From and at 212°	Pounds Steam Per Barrel Oil From and at 122° 336 Pounds Per Barrel.	Barrels Oil Per Hour Per Boiler Horse-power.
100	19.15	.0522	6434	.005360	19.52	.0512	6559	.005257
99	18.96	.0527	6371	.005412	19.32	.0517	6492	.005308
98	18.77	.0533	6307	.005473	19.13	.0522	6428	.005360
97	18.58	.0538	6243	.005524	18.93	.0528	6360	.005421
96	18.39	.0543	6179	.005575	18.73	.0533	6293	.005472
95	18.20	.0549	6115	.005637	18.54	.0538	6229	.005524
94	18.01	.0555	6051	.005699	18.34	.0544	6162	.005586
93	17.82	.0561	5988	.005760	18.15	.0550	6098	.005647
92	17.63	.0567	5924	.005822	17.95	.0557	6031	.005719
91	17.44	.0573	5860	.005883	17.75	.0563	5967	.005781
90	17.24	.0579	5796	.005945	17.56	.0569	5904	.005842
89	17.04	.0587	5725	.006027	17.37	.0575	5836	.005904
88	16.85	.0593	5662	.006088	17.18	.0582	5772	.005976
87	16.66	.0600	5598	.006160	16.98	.0589	5705	.006048
86	16.47	.0607	5534	.006232	16.79	.0596	5641	.006120
85	16.28	.0614	5470	.006305	16.59	.0603	5574	.006192
84	16.09	.0621	5406	.006377	16.40	.0610	5510	.006264
83	15.89	.0629	5339	.006459	16.20	.0617	5443	.006336
82	15.70	.0636	5275	.006531	16.00	.0625	5376	.006418
81	15.51	.0645	5211	.006624	15.81	.0633	5312	.006500
80	15.32	.0653	5147	.006706	15.62	.0640	5248	.006572
79	15.13	.0661	5084	.006789	15.42	.0648	5181	.006654
78	14.94	.0669	5020	.006870	15.23	.0657	5117	.006747
77	14.74	.0678	4956	.006963	15.03	.0665	5050	.006829
76	14.55	.0687	4889	.007055	14.83	.0674	4986	.006921
75	14.36	.0696	4825	.007147	14.64	.0683	4919	.007014
74	14.17	.0705	4761	.007240	14.44	.0692	4852	.007106
73	13.98	.0715	4697	.007343	14.25	.0702	4788	.007209
72	13.79	.0725	4633	.007445	14.05	.0712	4721	.007312
71	13.60	.0735	4569	.007548	13.86	.0721	4657	.007404
70	13.40	.0746	4502	.007660	13.66	.0732	4590	.007517

higher efficiencies are ideal only, but are given to complete the table. In actual practice boiler efficiencies vary from some less than 65 per cent. with the ordinary type of fire tube boiler to over 80 per cent. with the most improved type of water tube boiler having a specially constructed oil furnace. The highest record of boiler efficiency with crude oil under test conditions is 83 per cent.

STEAM DRIVEN AUXILIARIES.

The older method of determining steam consumption due to auxiliaries is to assume that the actual horsepower to drive auxiliaries is a certain percentage of the power delivered by main engine. This method makes no allowance for the economy of main engine, which is the most important quantity in determining the steam consumption of auxiliaries, nor does it consider the question of high or low vacuum, the quantity of circulating water used in the condenser or the head under which the circulating water is pumped. These facts, together with other important considerations, make it necessary to consider carefully every detail of the make-up of auxiliaries and their conditions of operation in order to determine even approximately the power required to drive the same.

The method herein presented is to calculate all quantities per pound of steam used by the main engine and finally to determine for the complete plant the total units of evaporation in the boiler from and at 212 degrees Fahrenheit per pound of steam used by the main engine, from which the total fuel consumption of plant is readily determinable.

The use of surface condensers is assumed throughout. In such a plant the following quantities are to be taken into consideration: Steam consumption of air pump, oil burners, radiation and leakage from main and auxiliary steam piping, and, in special instances, drains from engine jackets and reheating receivers. The power to drive air and circulating pumps depends entirely upon the amount of exhaust steam from main engine. The steam to drive boiler feed pumps, oil feed pumps, oil burners, and the radiation and leakage from steam piping are directly proportional to the total steam generated by the boilers, and only indirectly to the steam consumption of the main engine. The steps in the calculations are synthetically followed in the above order.

Before arriving at numerical results, it is necessary to assume the vacuum which the condenser is to maintain. Results have conclusively shown that in the larger surface condensing plants a vacuum of from twenty-five to twenty-eight inches is most economical, in spite of the lower temperature of the air pump discharge. The quantity of circulating water required must be increased from the old standard of from twenty-five to thirty pounds to from forty to sixty pounds of water per pound of steam condensed for moderate temperatures, and from sixty to 100 pounds of water per pound of steam when used at the higher temperatures common to cooling tower practice. In cases of excessive head or quantity of circulating water the bulk of the power required by auxiliaries is due to the circulating pump. The range of power for this purpose varies so widely that the older method of assuming a given type of plant requiring 5, 10 or 15 per cent. of the total steam consumption to drive auxiliaries is entirely in error without an accompanying statement defining conditions under which circulating water is pumped.

The power to drive the air pump is dependent somewhat upon the vacuum, but particularly upon the air leakage into the condensing system. It was for some time assumed that the work of the air pump corresponded to removing the air which entered the boiler in solution in feed water. As a matter of fact, handling the air in solution is the smallest portion of work done by air pump, the leakage through piping, pipe joints, pores of castings, stuffing boxes, etc., imposing the greatest duty, the total quantity of air to be handled ranging from ten or fifteen to thirty or forty times the air disolved in ordinary water. The actual power to drive the air pump should in good practice be less than .00018 indicated horsepower in the air pump cylinder per pound of exhaust steam per hour. As the amount of power necessary to drive the air pump is a comparatively small portion of the total power for auxiliaries a slight error in this quantity will not largely effect the final result.

The steam consumption necessary for oil burners under test conditions have been gotten down to less than 2 per cent. of the total boiler evaporation. The following calculations assume that

3 per cent. of the total steam will be required for oil burners under duty trial—1 per cent. to drive oil pumps and 2 per cent. for radiation and leakage from main and auxiliary steam piping.

It is further assumed that the exhaust steam from the feed pump, air pump and circulating pump passes to the feed water heater. The exhaust steam from oil pumps will be utilized in oil heating, and the steam to oil burners will be wasted up the stack. It is necessary to make allowance for the rise in temperature of feed water due to this auxiliary exhaust and as well to make proper allowance for the steam consumption per indicated horsepower for such auxiliary pumps as well as their mechanical efficiency. A small duplex feed pump will require about 200 pounds of steam per indicated horsepower. A compound direct acting feed pump of large size should require not to exceed 100 pounds of steam per indicated horsepower.

Such uneconomical types of pumps could not be used were it not for the fact that nearly all the heat from live steam is available in exhaust from pumps and is returned to the boilers through the feed water heater. The exact proportion of heat available is, however, determined by the economy of steam pumps and the proportion of the total available heat in live steam that is used in doing work. The accompanying Table No. 2 shows the assumed steam consumption of auxiliaries per indicated porsepower varying from 50 to 200 pounds and the corresponding total heat units per pound of live steam at 100 pounds gauge. Based on certain trials, it is assumed that in each case sixty heat units per pound will be lost, due to radiation from piping, pumps, etc. From the work done, the heat equivalent expended in work is calculated as shown. The remaining heat is available for heating feed water and the resultant rise in temperature for any assumed percentage of auxiliary steam wtll be as shown.

Based upon the above assumptions Table No. 3 is calculated giving results for small, medium and large plants, with different types of steam driven auxiliaries. All of the quantities assumed in this table are based upon one pound of steam consumption in the main engine. The quantity W × H represents the product-pounds of cooling water per pound of exhaust steam by total head in feet, including friction, on circulating pump. The total evaporation from and at 212 degrees Fahrenheit is the final quantity from which fuel consumption may be calculated.

In certain cases it will be noted that the duty on the circulating pump is excessive, a large percentage of the auxiliary steam passing to waste, being greater than the quantity that can be utilized in the feed water heater. In all cases 200 degrees Fahr. is the assumed limit of heating in the feed water heater, which is somewhat conservative. The last column of Table 3 shows the units of evaporation in boiler per pound of steam consumption of main engine, chargeable as the additional fuel for steam necessary to drive auxiliaries, over and above steam to main engine, after making due allowance for the heat returned through feed water heater. This quantity will be the basis of later comparisons of economies with steam- and electrically-driven auxiliaries.

It is stated above, that modern steam practice shows the advisability of high vacuum. This statement does not hold true in cases where the higher vacuum is produced under conditions of extreme head and quantity of circulating water, giving rise to a greater quantity of auxiliary exhaust than can efficiently be utilized in the feed water heater; so that where the percentage of steam to auxiliary heater is much in excess of 10 per cent. there will be a decided loss due to any further attempt to obtain an increase of vacuum. In such cases it is advisable to employ some more economical type of auxiliaries reducing their steam consumption. If all of the exhaust steam can be utilized, the temperature of feed being less than 200 degrees Fahrenheit, an error of 10 or 20 per cent. in estimating economy of auxiliaries gives rise to an error of less than 1 per cent. in the final result. This is clearly shown by comparison of first two examples under cases IV and V, Table No. 3.

TABLE NO. 2—SHOWING VARIATION OF FEED WATER TEMPERATURE DEGREES FAHRENHEIT.

CHAS. C. MOORE & CO., ENGINEERS (INC.) SAN FRANCISCO, CAL.

Pounds of Steam Per Indicated Horsepower of Auxiliaries.	British Thermal Units Per Pound of Steam Above 32° F. at 100 Pounds Gauge.	Radiation Loss British Thermal Units Per Pound of Steam	British Thermal Units Per Pound of Steam Expended in Work.	British Thermal Units Per Pound of Steam Above 32° F. After Deducting Radiation and Work.	British Thermal Units Per Pound of Steam Absorbed by Feed Case I.	Case I { Closed Heater. All Drains to Waste — Per Cent. Steam Used by Auxiliaries. 5 Per Cent. Degrees.	7.5 Per Cent. Degrees.	10 Per Cent. Degrees.	12.5 Per Cent. Degrees.	Per Cent Steam Used by Auxiliaries to Raise Feed to 200° F.	Case II. { a—Open Heater. b—Closed Heater. All Drains to Hot Well. — Per Cent Steam Used by Auxiliaries. 5 Per Cent. Degrees.	7.5 Per Cent. Degrees.	10 Per Cent. Degrees.	Per Cent Steam Used by Auxiliaries to Raise Feed to 200° F.
50	1185.9	60	50.9	1075.0	906.3	145.0	167.6	190.0	200.0*	11.1	150.1	174.7	200.0*	10.0
75	1185.9	60	34.0	1091.9	923.2	145.9	168.9	191.7	200.0*	10.9	150 9	176.0	200.0*	9.84
100	1185.9	60	25.5	1100.4	931.7	146.3	169.5	192.6	200.0*	10.8	151.3	176.7	200.0*	9.75
125	1185.9	60	20.4	1105.5	936.8	146.6	169.8	193.1	200.0*	10.75	151.6	177.0	200.0*	9.70
150	1185.9	60	17.0	1108.9	940.2	146.7	170.0	193.4	200.0*	10.7	151.8	177.2	200.0*	9.67
175	1185.9	60	14.5	1111.4	942.7	146.8	170.2	193.7	200.0*	10.67	151.9	177.4	200.0*	9.65
200	1185.9	60	12.7	1113.2	944.5	146.9	170.3	193.9	200.0*	10.66	152.0	177.6	200.0*	9.63

*This temperature of feed obtained without using all available heat.

NOTE—In Case I temperature of drains = 200° F. Temperature of hot well = 100° F.

In Case II temperature of air pipe discharge = 100° F. Temperature of hot well is that resulting from mixing drains and air pump discharge.

Maximum temperature of feed = 200° F.

TABLE NO. 3—POWER PLANT ECONOMY—STEAM DRIVEN AUXILIARIES. EXPRESSED IN POUNDS TOTAL EVAPORATION FROM AND AT 212° IN BOILER, INCLUDING OIL BURNERS, PER POUND STEAM CONSUMPTION MAIN ENGINE.

CHAS. C. MOORE & CO., ENGINEERS (INC.). SAN FRANCISCO, CAL.

Steam Used in Pounds Per Indicated Horse-power-Hour			Cooling Water W × H	Horsepower in Pump Cylinders			Pounds Steam Per Hour by Air, Circulating and Feed Pumps			Total Feed Water Pounds	Per Cent. Total Feed to Auxiliary Heater	Assumed Temperature of Hot Well	Temperature of Feed Water.	Factor of Evaporation	Total Evaporation From and at 212°	Total Evaporation From and at 212° +5 Per Cent.	Total Evaporation From and at 212° +10 Per Cent.	Units of Evaporation Chargeable to Auxiliaries.
Air	Circulating	Feed		Air	Circulating	Feed	Air	Circulating	Feed									
Case I.			**Small Plants—All Direct Acting Steam Pumps.**															
150	150	200	500	.00018	.000253	.000212	.045	.0473	.0530	1.2184	11.9	120	200	1.0611	1.293	1.358	1.422	.0653
Pump Efficiency.			1000	.00018	.000505	.000221	.045	.0947	.0553	1.2712	15.3	120	200	1.0611	1.349	1.416	1.484	.1178
			1500	.00018	.000758	.000230	.045	.1420	.0575	1.3240	18.5	120	200	1.0611	1.405	1.475	1.546	.1701
			2000	.00018	.001010	.000239	.045	.1894	.0598	1.3768	21.4	120	200	1.0611	1.461	1.534	1.607	.2226
60%	80%	80%	2500	.00018	.001263	.000248	.045	.2367	.0620	1.4294	24.0	120	200	1.0611	1.517	1.593	1.669	.2749
Case II.			**Medium Plants—All Direct Acting Steam Pumps.**															
100	100	150	500	.00018	.000253	.000205	.030	.0316	.0384	1.1702	8.5	110	187	1.0747	1.258	1.321	1.384	.0222
Pump Efficiency.			1000	.00018	.000505	.000211	.030	.0631	.0396	1.2050	11.0	110	200	1.0611	1.279	1.343	1.407	0409
			1500	00018	.000758	.000217	.030	.0948	.0407	1.2401	13.3	110	200	1.0611	1.316	1.382	1.448	.0755
			2000	.00018	.001010	.000223	.030	.1263	.0418	1.2746	15.5	110	200	1 0611	1.350	1.418	1.485	.1099
60%	80%	80%	2500	.00018	.001263	.000229	.030	.1579	.0429	1.3094	17.6	110	200	1.0611	1.389	1.458	1.528	.1445
Case III.			**Small Plants—C. & F. Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Feed Pumps.**															
55	50	200	500	.00018	.000253	.000204	.0165	.0281	.0510	1.1655	8.2	120	183	1.0789	1.257	1.320	1.383	.0334
Pump Efficiency.			1000	.00018	.000505	.000210	.0165	.0561	.0525	1.1969	10.5	120	200	1.0611	1.270	1.334	1.397	.0533
			1500	.00018	.000758	.000217	.0165	.0842	.0543	1.2287	12.6	120	200	1.0611	1.304	1.369	1 434	.0756
			2000	.00018	.001010	.000223	.0165	.1122	.0558	1.2601	14 6	120	200	1.0611	1.337	1.404	1.471	.1067
60%	45%	80%	2500	.00018	.001263	.000230	.0165	.1403	.0575	1.2919	16.6	120	200	1.0611	1.371	1.440	1.508	.1382
Case IV.			**Medium Plants—C. & F. Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Feed Pumps**															
55	30	150	500	.00018	.000253	.000202	.0165	.0253	.0380	1.1487	6.9	110	171	1.0915	1.254	1.317	1 379	.0196
Pump Efficiency.			1000	.00018	.000505	.000209	.0165	.0505	.0392	1.1768	9.0	110	192	1.0695	1.259	1.322	1.385	.0227
			1500	.00018	.000758	.000215	.0165	.0758	.0403	1.2049	11.0	110	200	1.0611	1.279	1.343	1.407	.0408
			2000	.00018	.001010	.000222	.0165	.1010	.0416	1.2331	12.9	110	200	1.0611	1.308	1.373	1.439	.0688
60%	50%	80%	2500	.00018	.001263	.000228	.0165	.1263	.0428	1.2613	14.7	110	200	1.0611	1.338	1.405	1.472	.0968
Case V.			**Large Plants—C. & F. Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Feed Pumps.**															
35	40	100	500	.00018	.000253	000196	.0105	.0184	.0245	1.1206	4.8	100	150	1.1134	1.248	1.310	1.373	.0042
Pump Efficiency.			1000	.00018	.000505	000199	.0105	.0367	.0249	1.1405	6.3	100	165	1.0977	1.252	1.315	1.377	.0073
			1500	00018	.000758	000203	.0105	.0551	.0254	1.1606	7.8	100	180	1.0821	1.256	1.319	1.382	.0099
			2000	.00018	.001010	.000206	.0105	.0735	.0258	1.1806	9.3	100	195	1.0663	1.259	1.322	1.385	.0118
60%	55%	80%	2500	.00018	.001263	.000210	0105	.0919	.0262	1.2009	10.7	100	200	1.0611	1.274	1.338	1.401	.0255
Case VIA			**Small Pumping Plants—Direct Acting Air and Feed Pumps; no Circulating Pumps.**															
150		200																
Pump Efficiency.			.....	.00018	.....	.000202	.0448	.....	.0505	1.1630	8.2	120	185	1.0743	1.249	1.311	1.374	
60%		80%																
Case VIB.			**Non-Condensing Plants—Direct Acting Feed Pumps.**															
		200																
Pump Efficiency.			.....	.....	.....	.000194	.....	.....	.0485	1.1154	.....	.....	200	1.0611	1.184	1.243	1.302	.....
		80%																

NOTE—Boiler pressure is assumed 150° gauge throughout.

All drains are discharged into hot wells.

Column "Cooling Water—W × H" gives weight of water per hour in pounds × total head in feet on circulating pump.

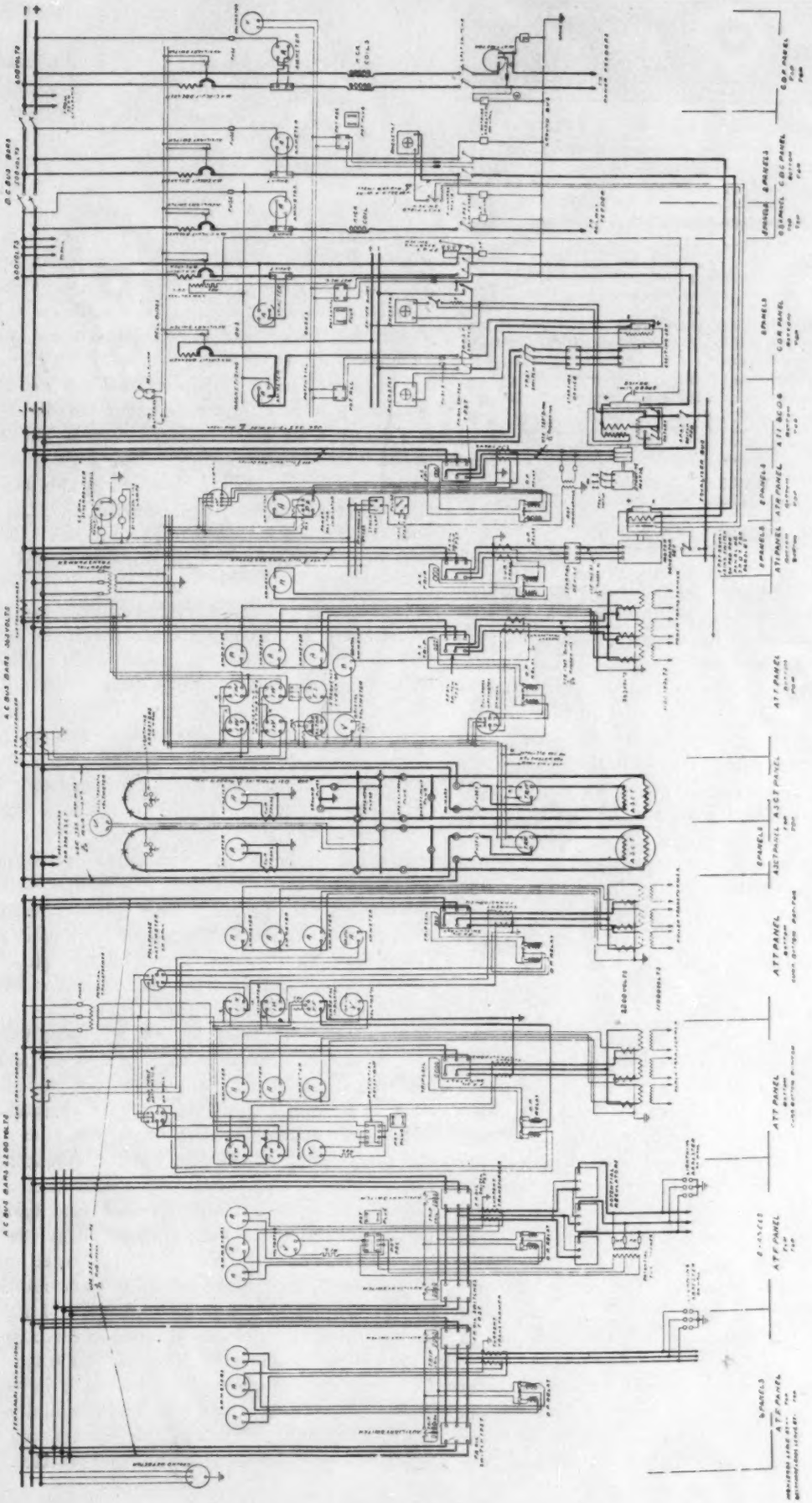
In Case VIA condenser is placed in suction or discharge pipe.

The above table allows 3 per cent. of total evaporation for oil burners, 1 per cent. for oil pumps, 2 per cent. for radiation.

Last column gives net—from and at 212 degrees—steam equivalent to drive auxiliaries allowing for return of exhaust steam in feed water.

The above figures will be modified in case of plants having economizers or superheaters.

Wiring Diagram of the Main Switchboard of the Substation of the Helena Light and Traction Company, Helena, Mont.



In THE JOURNAL for December last (Volume XIV, page 475) there appeared a detailed description of the new and remarkably complete substation of the Helena Light and Traction Company, at Helena, wherein power for the operation of every electrical industry of Montana's Capitol city is taken from the Canyon Ferry plant of the Missouri River Power Company and reduced to arc and incandescent, polyphase and direct current power and electric railway services. Since that article appeared, however, additional information has been received concerning the electrical connection of its switchboard, the details of which are above presented as supplemental to the main article already published.

The Journal of ELECTRICITY, POWER and GAS
DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

PUBLISHED MONTHLY BY
The Journal of Electricity Publishing Company
Room 532, Rialto Building, San Francisco, Cal.
Telephone Main 1264.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $2.00; Foreign, $2.50; Single Copies, 25 cents.
Subscriptions can not be begun with back numbers.
Manuscripts submitted must be accompanied by postage to insure return.

ADDRESS ALL COMMUNICATIONS AND MAKE ALL REMITTANCES PAYABLE TO THE JOURNAL OF ELECTRICITY PUBLISHING COMPANY

This paper is a member of the National Trade Press Association.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.
Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

VOLUME XV MARCH, 1905 NUMBER 3

EDITORIAL.

EFFICIENCY TESTS OF AN IMPULSE WATER WHEEL.

It will be evident to every engineer who reads the description of a series of tests of an impulse wheel made by Professor Joseph N. Le Conte at the University of California, and the publication of which is to begin in THE JOURNAL for April, that they are very interesting and have been carried out with extreme care. To add to their value they were made on standard mining types of wheels produced by the Pelton Water Wheel Company, of San Francisco and New York, and in no case was the apparatus under test specially produced or given more attention in manufacture than is ordinarily bestowed on standard products.

Some general observations regarding the conclusions to be deduced from these tests will be pertinent. One of them was made under the low head of 44.76 feet, when the nozzle gave an efficiency of 96.2 per cent. and the wheel attained an efficiency of 78.3 per cent. Throughout the serial Professor Le Conte has subdivided the losses in a way that shows very readily the remarkable efficiency attained by the Pelton bucket, and in this particular test referred to the bucket and discharge losses combined amount to but 15 per cent., and, therefore, eliminating windage, friction and nozzle losses, the buckets gave 85 per cent. efficiency. The small amount of power involved at which this wheel was tested would, of course, make the windage, friction and nozzle losses much greater than they would be in a commercially operated wheel of larger capacity. The serial also presents a series of efficiency measurements on the nozzle tips, from which it will be noticed that these run up to 98.8 per cent.

The efficiency tests that are grouped on elsewhere in the article give the best insight into the high results obtained with this type of wheel. It will be observed that as the head increases the efficiency for the same size of nozzle increases, but it is unfortunate that the pumps used did not have a sufficient capacity to enable the larger sizes of streams to be used under high pressure on this wheel. The nozzle bored 1.474 inches gave an output corresponding with 76.9 per cent. efficiency under forty-five feet effective head, and increased to 78.5 per cent. efficiency under the 140-foot head, showing an increase of 3.6 per cent. efficiency. It is probably fair to assume that this percentage would be further increased under even higher heads, as shown by the .8795 inch nozzle, which increased 2.6 per cent. more between 140 feet and 312 feet, and, therefore, had the proper sized stream, namely, a two-inch stream, been used on this bucket under the 312-foot head, the efficiency would undoubtedly have exceeded 85 per cent.

The table showing efficiencies on wheel No. 2 would be misleading were it not stated that the four-inch bucket was designed for a stream smaller than the 1.474 inch nozzle used; therefore, the efficiencies given for the streams above one inch in diameter in this table are for the bucket considerably overcrowded, and it is worthy of note that the efficiency under the 140-foot head remains as high as it does, even for this overcrowded condition.

Another very interesting point in Professor Le Conte's investigation is the comparison between the needle nozzles and the plain nozzles under identical conditions, In this case the plain nozzles show a decidedly higher efficiency than the needle nozzles; but in making this comparison it must be borne in mind that the plain nozzle curve is made from points obtained with nozzles correctly bored for different sizes of streams and is not the curve obtained with a single plain nozzle varying the wheel speed by manipulating the gate. This comparison shows that although the needle nozzle develops a remarkably good full load efficiency, this still falls below that obtainable with a properly bored straight nozzle; but it also shows that the needle nozzle is quite a satisfactory device for partial loads. The final test given shows a bucket loss of but 13.9 per cent., corresponding with a bucket output of 86.1 per cent. efficiency.

With these high laboratory efficiencies on Pelton buckets that are not ground or built for any particular set of conditions, there can be little doubt but that Pelton wheels as carefully designed and built as those furnished in the last few years by that company to power transmission plants, such as the No. 3 Mill Creek station of the Edison Electric Company, operate with an efficiency well above 80 per cent. It will be remembered that Professor Le Conte's test of the Pelton wheel under the 1960-foot head at the Mill Creek No. 3 station, showed an output of 86.2 per cent., including windage and journal friction, the loss in the nozzle and in the buckets, and making only such allowances for electrical losses as established by the electrical manufacturers. The buckets which Professor Le Conte has tested, we are informed, have not been ground or polished in any way, and it would be interesting to learn what advantage this feature, for which so much has been claimed, has in actual practice.

ON THE ECONOMY OF STEAM PLANTS.

The cost of steam power on the Pacific Coast is a very interesting subject to all engineers and managers who are concerned in power production and transmission, and the serial article begun in this issue on the above subject is a very timely one. The article is written for THE JOURNAL by the Engineering Department of Chas. C. Moore & Co., Engineers (Inc.), of San Francisco, who have had an extended experience in designing and erecting plants under Pacific Coast conditions, and it contains full and complete tables enabling cost to be computed under varying conditions as to size of plant, load factor, price of fuel, etc.

The extensive development of water power plants on the Pacific Coast within the last few years has attracted wide spread interest, and during this interval the steam power plant has in a measure failed to keep up the pace. Of late, interest in the steam plant has, however, been largely revived, owing to the very low price of fuel oil, to the attainment of greater possible economies due to improved vacuum, to higher steam pressures, and to superheated steam. While there are numerous steam power plants on this coast employing fairly modern machinery, there are very few in which all of the latest developments of steam engineering are carried out on a large scale. On this account the average idea of power costs, based on existing plants, is not fair to the best steam engineering practice.

For instance, assuming a 20,000-kilowatt modern station, with uniform load, it is possible to develop, on a twelve-hour duty trial, 240-kilowatt-hours per barrel of fuel oil, all possible economies being introduced. This is taken from the tables in the article commented on.

Were it possible to secure a service maintaining 100 per cent. load factor for 8760 hours per year, it would also be possible, with fuel oil at 50 cents per barrel, to deliver power on the switchboard at a cost of 0.41 cents per kilowatt-hour, or with oil at 75 cents per barrel, at a a cost of 0.53 cents per kilowatt-hour. The figures include operating expense, and interest and depreciation charges.

It is, of course, impossible in commercial power plants to ever realize conditions of service that will give a 100 per cent. load factor, and with reduced load factor all items entering into the unit cost for power necessarily increase. It is also an undoubted fact that very few, if any, plants are operated during regular service under the conditions which tend to highest fuel economy.

The above figures, however, represent the ideal conditions, and really indicate the limit towards which the cost of power production may approach.

The actual conditions of a large steam power plant may be taken as those obtaining in a central station for light and power service, or those obtaining in a power station for street railway work. In the case of the former, the load factor for the year, or the ratio of the average load for the year to the winter peak, will not greatly exceed 25 per cent. unless abnormal conditions as to load exist. In the case of the latter, the load conditions are somewhat better, probably ranging between 33⅓ per cent. and 50 per cent. being in a measure dependent on the character of the service and the sharpness of grades on the various lines.

The results which may be attained in a well designed and carefully operated station under these conditions are as follows, the figures being based on interest at 5 per cent., depreciation 5 per cent., maintenance 2 per cent., taxes and insurance 1 per cent. and rates of labor taken from actual practice:

With fuel oil at 50 cents per barrel, the cost per kilowatt-hour at 50 per cent. load factor is 0.60 cents; at 33⅓ per cent. load factor, 0.75 cents; at 25 per cent. load factor, 0.92 cents. With fuel oil at 75 cents per barrel the cost per kilowatt-hour at 50 per cent. load factor will be 0.74 cents; at 33⅓ per cent. load factor, 0.90 cents, at 25 per cent., load factor, 1.05 cents.

The actual results obtained in the plant of the Independent Electric Light and Power Company, of San Francisco, prior to its consolidation with the San Francisco Gas and Electric Company, taking cost items on the above basis, the fuel cost being 72½ cents per barrel, and the load factor being between 25 and 33⅓ per cent., was 1.18 cents.

The attainable figure as given above is between 0.92 and 1.05 cents, which leads to the belief that it is safe to say that the rates of cost as originally given are not reached in actual practice in any station on the coast.

It should be born in mind that the Independent plant was installed without superheaters, was operated under somewhat less vacuum than is now obtainable, that the furnaces were less efficient than furnaces since devised, and that the units are about half the size of those contemplated in the above plant of 20,000 kilowatts capacity. Bearing these features of possible improvement in mind, the comparison is rational.

There are many reasons for this: failure to detect and remedy small losses and failure to keep all parts of the plant keyed up to maximum point of efficiency are considerable factors, but lack of intelligence in the boiler room is in most instances accountable for a large part of the discrepancy. Under extremely careful adjustment of burners and draft, fuel oil may be successfully burned under a boiler with only 10 per cent. of air supply in excess of that chemically necessary for its combustion. Recent tests of a number of plants have shown an excess of from 100 to 300 per cent., the fuel consumption on this account being increased from 10 to 20 per cent. above what it should be under best conditions.

That this condition of affairs should exist in plants using such an ideal fuel as crude oil is certainly lamentable. It is certain that station managers and chief engineers are not fully keeping pace with the most advanced practice of steam engineering. Although there exists of necessity a certain disparity of results, the lack

of intelligent supervision in the boiler room and more earnest endeavor to take advantage of the economies so easily attainable renders many of our operating engineers subject to censure. Improvement can only be obtained by the use of more intelligent and skilled firemen. The saving of fuel will unquestionably be many times the additional labor cost.

The costs given above will naturally be larger in the case of smaller plants. It may be stated, however, that even in plants of from 300 to 500 kilowatts the cost of production can be brought surprisingly low if the plant is properly designed and operated.

The human element can never be eliminated from any problem, and given a plant of the most efficient type it is possible in a very short time to let it run down to a point where fuel cost per unit of power is largely increased.

THE SAN FRANCISCO BRANCH AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

As already announced in these columns as well as in the January number of the proceedings of the American Institute of Electrical Engineers, a San Francisco branch was authorized December 23, 1904, its organization having been completed by the election of the following officers for the ensuing year: Major Geo. O. Squier, Chief Signal Officer, Department of California, U. S. A., chairman; Prof. C. L. Cory, vice-chairman; A. H. Babcock, secretary; and the executive committee to consist of Messrs. Geo. O. Squier, C. L. Cory, A. H. Babcock, J. A. Lighthipe, F. V. T. Lee. These elections have been approved by the Institute.

Through the courtesy of the librarian of the Mechanics Institute quarters have been provided for the meetings of the branch, which will be held monthly on the first Tuesday of the month, at 8 p. m., at the Mechanics Institute Library, No. 31 Post Street, San Francisco.

In order that an intelligent discussion may be aroused, advance copies of papers for discussion will be received from the Institute and distributed by the local secretary to the members of the San Francisco branch. It is the intention to arrange to have the papers abstracted and read by members appointed by the executive committee. Due notice will be given to all members of the meetings and papers to be discussed.

The local secretary has endeavored to communicate with all members and associates of the American Institute of Electrical Engineers in and about San Francisco, but until the official list of members is received from the secretary, it is not certain that all resident members have been reached. Members are therefore requested to bring the matter to the attention of other members of their acquaintance and, in general, to give as much publicity as possible to the formation of the branch in order that the omissions may be reduced to the lowest possible number.

Since one of the most important objects in forming local branches is to create a center of activity in electrical matters, members are expected to bring to the meetings all who are interested in the subject whether they be connected with the Institute or not.

The executive committee expects to keep the expenses of the branch within the allowance made by the Institute, and that it will not be necessary to have any local dues, but the results shown will go a long way toward determning the allowance that the Institute will grant to the branch.

An esplanade one mile long extends along the lake front at the Lewis and Clark Centennial at Portland. Visitors may promenade along this walk at night and obtain an excellent view of the electrical effects on the grounds and buildings.

OBITUARY.

Edward Hemphill Mullin, well known to electrical and newspaper men, died suddenly from an attack of heart disease on January, 25th, at his home in Milburn, N. J. Mr. Mullin was born in Castlederg, County Tyrone, Ireland, on October 22, 1850. He was educated at the Methodist College Public School of Belfast and the Queen's College, Belfast, where he took his bachelor's degree with honors in physics and chemistry in 1881. Shortly afterward he came to New York and engaged in newspaper work. From 1887 to 1895 he was an editorial writer on the staff of the New York *Evening Sun*. The two following years he spent on the staff of the New York *Times*, in charge of the technical reporting of that newspaper. Subsequently he became editor of the "Bookbuyer" and a prolific contributor to the magazine and technical press.

On February 1, 1898, he entered the service of the General Electric Company, at first as manager of its advertising department and latterly as a confidential representative of the company in many matters. He was the authorized representative of the company in all its relations with the press and the official host of the company wherever foreign engineers or capitalists desired to visit its works or become acquainted with its methods. He was a thirty-second-degree Mason and a member of the Engineers', Press, Lotus and Transportation clubs. He was vice-president of the New York Electrical Society and a manager of the American Institute of Electrical Engineers; also vice-president of the Association of American Advertisers. Mr. Mullin had a large number of friends in New York and abroad and was known among them for his erudition and wide acquaintance with electrical and engineering subjects. He was a consistent student and an able writer.

ONE WAY OF GETTING CONSUMERS.

THE means employed by the Denver Gas and Electric Company for educating the people of Denver, Colo., to the use of gas and electricity can be looked into and the effort justified by the gas and electric fraternity wherever located. That a constant suggestion of the advantages to be gained by the use of a meritorious article will undoubtedly convince the most skeptical of the expediency of purchasing it is a well recognized fact. Such is apparently the opinion of the Denver Gas and Electric Company, as indicated by the regular intervals of its dissemination of the reasons why gas and electricity should be used, and the suggestion is potent in each effort that the Denver Gas and Electric Company can supply the demand.

A letter came one morning giving the active record, names and addresses of a number of people who had installed gas ranges in Denver. Later there was received the first installment of a serial article entitled "What Did Abe Say?" The story was in three installments, and curiosity became keyed up to a high point in anticipating what Abe would say. Abe said get a heater free. This was followed by other cards bearing names and addresses of people who had installed gas ranges. The latest result of the genius employed in carrying on the campaign of education, is a booklet entitled "Nice Wife—Nice World," in which is set forth a strikingly illustrated and delicately worded story which would almost impel a man who lived a hundred miles from a source of supply to pipe and wire the distance and reap the enjoyment of the use of that commodity which the Denver Gas and Electric Company has to offer.

One is impelled to ask the question: What Next? and to insist that the good work which has been so admirably conducted go on, for it is without doubt the key to open the way for the entry of gas and electricity into nearly every home in Denver.

PERSONAL.

H. D. Scribner, formerly sales agent for the San Francisco office of the Westinghouse Electric and Manufacturing Company

and more rcently representative of the same concern for British Columbia with headquarters at Vancouver, has resigned from the Westinghouse Company to accept a responsible position in the service of the Allis-Chalmers Company.

C. O. Poole, who is well known to the electrical fraternity of California and chief engineer for the Hendrie and Bolthoff Mine and Smelter Supply Company, of Denver, has accepted the consulting electrical engineership of the Nevada Power, Mining and Milling Company, of which R. M. Jones is constructing and hydraulic engineer. This company is to develop power at Bishop Creek, Inyo Company, California, for transmission to Tonopah and Goldfields, Nev.

Carl H. Renter, formerly of the Sacramento Electric, Gas and Railway Company, has been appointed manager of the Vallejo Gas and Electric Company—the latest acquisition of the California Gas and Electric Corporation.

NEW INCORPORATIONS.

SAN FRANCISCO, CAL.—Standard Electrical Works, by R. J. Davis, Harrison Dibblee, A. L. Funk and others; capital stock $100,000.

VISALIA, CAL.—The Consolidated Heat, Light and Power Company, by Wm. Thomas, Mark L. Gerstle, Woodly B. Smith and others; capital stock $300,000.

MARYSVILLE, CAL.—The Marysville Gas and Electric Company has been incorporated by C. M. Petersen, A. C. Bingham, Mary A. Knight and others; capital stock $500,000.

CHICO, CAL.—The Chico Construction Company has been incorporated by H. A. Patterson, F. M. Clough, S. B. Norse and others with a capital stock of $25,000 for the purpose of engag ing in all kinds of construction work including electrical enterprises.

FINANCIAL.

SAN FRANCISCO, CAL.—On February, 25th, the Northern California Power Company paid its twelvth monthly dividend of five cents per share.

SANTA ANA, CAL.—The bonds in the sum of $100,000 voted for an extension of the water works system have been sold to N. W. Harris, of Pasadena, for accrued interest and $9011 premium.

SACRAMENTO, CAL.—The South Yuba Water Company and its distributors, the Central California Electric Company, have been absorbed by the California Gas and Electric Corporation. At present, however, the properties will be operated under separate managements as heretofore.

HOLLISTER, CAL.—Messrs. Driukwater and Crong, Eastern capitalist, have bought the entire stock of the Hollister Water Company, and the Hollister Light and Power Company, and after consolidating the two properties will make extensive improvements in both during the coming spring.

SAN FRANCISCO, CAL.—The gross earnings of the United Railroads of San Francisco to December 31, 1904, show: December, 1904, $572,500; December, 1903, $560,384; increase, $12,116; twelve months, 1904, $6,100,395; twelve months, 1903, $5,670,614; increase, $429,781. The increase in gross earnings in 1903 was $704,299.

PORTLAND, OR.—At the annual meeting of the stockholders of the Portland Consolidated Railway Company held on January, 25th, the following were elected for the ensuing year: A. L. Mills, president; C. F. Swigert, vice-president; J. C. Ainsworth, treasurer; F. I. Fuller, general manager, W. A. White, of New York, being the fifth director.

HONOLULU, T. H.—At the annual meeting of the stockholders of the Kona-Kau Telephone and Telegraph Company (Ltd.), the following named were elected as officers of the company for the ensuing year: J. A. Maguire, president; G. C. Hewitt, vice-president; L. S. Aungst, secretary and treasurer; W. H. Greenwell, auditor, and John Gaspar, M. F. Scott, J. K. Nahale, directors.

SAN FRANCISCO, CAL.—The Mutual Electric Light Company has filed with the Supervisors a statement showing that in 1904 its revenue amounted to $116,416.71 and its expenses to $94,967.63. The original cost of the plant was $479,787.27, but its present value is "impossible to estimate." The capital stock consists of 50,000 shares at $10 each and 41,250 shares have been issued. The outstanding bonds amount to $193,000 and the floating indebtedness to $10,478.58.

SAN FRANCISCO, CAL.—The Union Trust Company has received a deed of trust from the Humboldt Transit Company, of Eureka, for all of its property now owned by it, or to be acquired, the latter including the rights of way and other appurtenances to the proposed extension of its electric railway. The deed was given to secure the bond issue of the company for $1,000,000 of 5 per cent. first mortgage bonds, 1000 in number, payable at the end of thirty years, which bonds were to be floated by the Trust Company. The new stockholders now purpose going ahead with the extension of the road and the bonds will now be issued.

SAN FRANCISCO, CAL.—The financial statement of the San Francisco Gas and Electric Company for the year ending Dec. 31, 1904, as filed with the Board of Supervisors, is as follows: Total receipts, $4,396,859.08; expenses, $3,331,425.33; net profit $1,065,433.75; dividends; $792,421.68; surplus, $273,012,07. The original cost of the plant is stated to be $13,042,578.55, and its present cost and value is fixed at $26,053,756.62. The capital stock outstanding amounts to $15,794,284.36, bonds outstanding $9,813,000 and net amount of floating debt $816,934.19. For the year ending Dec. 31, 1903, net earnings amounted to $574,956.60, while the floating indebtedness on Dec. 31, 1903, amounted to $1,091,492.65, a reduction for the year of $274,558.46.

HONOLULU, T. H.—During the annual meeting of the stockholders of the Rapid Transit and Land Company held on January 26th, the following officers were elected for the coming year: President, L. Tenny Peck; first vice-president, L. A. Thurston; second vice-president, James B. Castle; manager, C. G. Ballentyne; secretary, George P. Thielen; treasurer, Charles H. Atherton; auditor, F. W. Klebahn. These with W. R. Castle constitute the directorate. The report of the manager showed that the total mileage traveled during the past year had been 1,476,369 miles, and that the number of passengers carried was 6,689,401 which if the population of Honolulu is reckoned at 40,000 is equivalent to a per capita of 167. The total income of the company for the year was $332,173.62. The total operating expenses and fixed charges was $252,346.05. The net income was $79,827.57.

SAN FRANCISCO, CAL.—N. W. Harris & Co., in offiering a block of the Valley Counties Power Company, first mortgage 5 per cent. sinking funds bonds yielding 4.90 per cent. per annum for sale at $101.50, state: "The bonded indebtedness of the Valley Counties Power Company is $2,500,000, which is due on May 1, 1930, and is a first lien on all the property of this company now owned, or to be acquired, and payment is also guaranteed by the Bay Counties Power Company which owns all the stock. A sinking fund is provided by annual payments out of earnings amounting to $25,000 per annum for five years from Nov. 1, 1905; $37,500 per annum for five years from Nov. 1, 1910; $50,000 per annum for five years from Nov. 1, 1915; $62,500 per annum for five years from Nov. 1, 1920, and $75,000 per annum for five years from Nov. 1, 1925. Interest is payable semi-annually on May, 1st snd November. 1st. The earnings of the Valley Counties Power Company for the year 1904 were: Gross earnings, $254,243.91; operating expenses, $42,915.11; interest on $2,500,000 first mortgage bonds, $125,000.00; surplus, $86,328.80. "The operating expenses are said to be small owing to the fact that the general and office expenses are assumed by the California Gas and Electric Corporation. The engineer's report states that the property has water powers capable of development sufficient to add at least 20,000 horsepower, and probably largely in excess of 50,000 horsepower to the present generating capacity of 15,600 horsepower. The Valley Counties Power Company has

a valuable contract with the Bay Counties Power Company running up to 1932 providing for the sale of all its surplus power now being developed or that may be developed in the future. An application will be made for listing at Stock and Bond Exchange."

SAN FRANCISCO, CAL.—The comparative statement of the California Gas and Electric Corporation for the month of December show the following increases: Gross earnings, $158,069.84; expenses, $117,471.41; profit, $40,598.43; corporation bond interest, $3,125; and net surplus, $37,473.43. As will be seen by the official statement, the net surplus after all charges are deducted amounted to $85,535.10 for December; the monthly dividend of 25 cents per share required $25,000, so that $60,535.10 is left, a very handsome profit for the month.

The official statement of earnings for December 1903 and 1904, is:

	1903	1904
Gross earnings	$277,943.30	$436,013.14
Operation maintenance, taxes, insurance and bond interest of subsidiary companies	184,048.30	301.519.71
Profit	$ 93,895.00	$134,493.43
Corporation bond interest	33,333.33	36,458.33
Balance	$ 60,561.67	$ 98,035.10
Sinking fund	12,500.00	12,500.00
Net surplus	$ 48,061.67	$ 85,535.10

For the ten months to December 31, 1904, gross earnings increased $1,194,642.71, profits over cost of operation increased $263,127.84, and net surplus over all expenses and charges, including proportion of sinking fund, increased $226,163.62

The comparative statement of earnings and expenses for the ten months to December, 31st is as follows:

	1903.	1904.
Gross earnings	$2,338,930.33	$3,533,573.04
Operation, maintenance, taxes, insurance and bond interest of subsidiary companies	1,675,002.84	2,606,517.71
Profit	$ 663,927,49	$ 927,055.33
Corporation bond interest	327,619.11	364,583,33
	$336,308.38	$562,472.00
Sinking fund	125,000.00	125,000,00
Net surplus	$211,308.38	$437,472.00

TRANSMISSION.

MEDFORD, OR.—The Condor Water and Power Company is to install a 4000 horsepower plant at Gold Ray for transmission to Medford.

BINGHAM, UTAH—The General Electric Company has secured a contract for an electric haulage system to be installed in the mines of the Utah Copper Company.

SONORA, CAL.—The National Park Electric Power Company has been incorporated by J. J. Inman, M. E. Page, J. H. Rucker and others with a capital stock of $250,000.

SEATTLE, WASH.—It is reported that J. J. Hill and Colonel J. N. Peyton propose to build a smelter and a great hydro-electric plant at Kettle Falls on the Columbia River.

WALLULA, WASH.—The Continental Construction Company is to sub-contract the earth excavation for the power canal which it is building on the Snake River at five mile rapids.

CITY OF MEXICO, MEX.—Chas. A. Hamilton is working on a plan of putting an electric power plant in the Ejutla district, State of Caxaca, the machinery for which will be imported from the United States.

ARCATA, CAL.—The Arcata Light and Power Company is to erect a substation on the corner of Sixth and I streets, this city, to be operated from the transmission circuits of the North Mountain Power Company.

FRESNO, CAL.—The San Joaquin Power Company has decided to begin at once the construction of another power plant in the mountains near the Crane Valley reservoir. The plant will have a capacity of 3500 horsepower.

SAN BERNARDINO, CAL.—The Arrowhead Reservoir Company has signed contracts for the building of a $500,000 dam across Little Bear Valley wherein water will be stored for irrigation and possibly for the development of power.

LAS CRUCES, N. M.—The Mine and Supply Company of Butte, Mont., and the City of Mexico, has awarded the contract for the foundation of the electric power plant which will furnish this city with water, electric light and power. An ice plant is also to be built.

SAN FRANCISCO, CAL.—The California Gas and Electric Corporation has bought forty acres of land in San Mateo County on the bay shore near the seven mile house whereon to erect the 15,000 horsepower gas engine generator plant of the San Mateo Power Company.

TORREON, MEX.—The Lujan Bros., of this city, together with a Mr. Mueller, of Chihuahua, are completing plans for the construction of a large masonry dam across the Valle River from which it is probable that electricity will be developed for transmission to Parral.

SACRAMENTO, CAL.—The Bay Counties Power Company is to erect two huge suspension towers to be located respectively on the water front of this city and in Washington, Yolo County, for supporting across the Sacramento River, the additional transmission lines which it is building.

CHIHUAHUA, MEX.—Julio Miller and Ramon Lujan both of this city will at once begin the construction of a large irrigation system incidental to which will be the development of power for operating an electric lighting plant for supplying all characters of electric service to the town of Allende.

MARYSVILLE, CAL.—James O'Brien, of Smartsville, and J. E. Ebert and L. H. Mitchell, of Marysville, have filed a notice of location of claim to 100,000 inches of the water of the Yuba River, to be diverted at the point nearest Smartsville, known as "The Narrows," by means of a dam which will cost $800,000.

SANTA ROSA, CAL.—In order to overcome the disadvantage of the single transmission line on which continuity of service in Napa Sonoma and Marin counties is now dependent, the California Central Gas and Electric Company will, it is stated, build an independent transmission line from Colusa to Santa Rosa.

CITY OF MEXICO, MEX.—The Mexican-American Power Company has been incorporated with a capital stock of $150,000 by J. H. DeVictor, G. S. Simmons and B. H. Welch for the purpose of developing electric transmission service in Mexico. The principal office of the company is at 417 Market Street, San Francisco.

BOISE, IDAHO—D. C. Nevin, of Weiser, Idaho, and who is general manager of the Iron Springs Mining Company, states that during the summer his company will install an electric power transmission plant to operate all the machinery at the reduction works which will consist principally of a 500-ton cyanide plant.

SAN LEANDRO, CAL.—William Angus, manager of the Suburban Electric Light Company, has applied for a franchise permitting the erection of a transmission pole line throughout San Joaquin County to supply Tracy, Bethany and the farming and orchard districts about Stockton with electric transmission service.

POMONA, CAL.—The farmers hereabouts have appointed a committee consisting of J. E. Adamson, H. J. Nichols, W. A. Lewis and G. P. Robinson to investigate the feasibility of establishing a big central electric power plant to furnish current for the many small pumping plants in the vicinity. If the plan goes through the power will be used for other purposes also.

REDDING, CAL.—The Northern California Power Company has completed the four mile extension of its transmission line from its Balakalala substation to Mammoth, whence the line will be

continued to Kennet, a further distance of one and one-half miles. In all, some 700 horsepower will be delivered over this new line to the Mammoth Mine and Smelter and through Kennet.

PRESCOTT, ARIZ.—The Arizona Power Company, of which R. S. Masson of Los Angeles is chief engineer, and which was formerly known as the Fossil Creek Electric Company, has a large force of men at work driving tunnels near Fossil Creek preparatory to the installation of its plant which will develop 6000 horsepower for distribution to the mining and electrical companies of Yavapai County.

SAN FRANCISCO, CAL.—The Truckee River General Electric Company has closed a contract with the Westinghouse Electric and Manufacturing Company for a 1500-kilowatt generator, which is to be installed at the new plant, six miles from Floriston, on the Truckee River. It will be in operation next fall, supplying power to the Comstock mines under the new contract, as well as furnishing light and power in the Truckee River district.

EVERETT, WASH.—A. H. Fritz and F. H. Bonda, mining men from Alaska state that funds have been secured by manager Havecker for carrying on extensive development work that has been planned for the wayside mine, principal among which will be the installation of a 3500 horsepower transmission plant to be operated from water taken from the Stillaquamish River near Robe and conducted thence to Hubbard Lake, which will be used as a reservoir.

LOS ANGELES, CAL.—The Luitweiler Pumping Engine Company, of Los Angeles, has just shipped one of its electrical driven deep well mining pumps to the Moctezuma Copper Mining Company of Nacozari, Mex, and also one to the Potosina Electric Company at San Louis Potosi, Mex. The company is also building one for the Chihuahua-Pacific Railway of Chihuahua, Mex. The Luitweiler Company is devoting all its attention now to the production of deep well pumping machines for mines and municipal water works.

SAN FRANCISCO, CAL.—The Eel River Power and Irrigation Company has been incorporated with a capital stock of $500,000 by H. B. Muir, of Willits, R. E. Donohoe and W. P. Thomas, of Ukiah, W. W. Van Arsdale and F. D. Madison. The company proposes to develop the power of Eel River in Humboldt County for general transmission purposes. Water for the operation of the system is to be diverted from Eel River and carried through a 5000-foot tunnel to the upper end of Potter Valley where the plant will be located. After passing through the power house the water will be used for the irrigation of Potter and Ukiah Valleys and possibly for domestic service in Ukiah.

BISHOP, CAL.—The Nevada Power, Mining and Milling Company, the principal office of which is at 302 Boston Building Denver, Colo., will at once begin work on the transmission which it is to install from Bishop Creek to Tonopah and Goldfields, Nev. Contracts for all the machinery will have been let prior to March 1st. Engineer L. B. Curtis states that the head of the pipe line will be near the old brewery on Bishop Creek, and the power plant will be located about half a mile below the mouth of Coyote Creek, near the Indian ranch. The pipe line will be two and one-third miles long, and will have 1060 feet fall. The amount of water used will be twenty-four second feet, or 1200 inches. Two 750-kilowatt generators will be installed as a beginning. The intention is to deliver 2000 horsepower in Goldfields. The wires will run northeasterly to a point directly west of Laws, then to and past the latter point along the country road.

HONOLULU, T. H.—Details of the transmission system to be installed for the McBryde Sugar Company operating under the name of the Kauai Electric and Power Company have been published from which it appears that the water is to be taken from the Winiha Valley River and carried for a distance of about five miles along the sides of the Rock Canyon to a point giving a head of 550 feet where 4000 horsepower will be developed. The ditch will consist almost entirely of rock tunnels piercing the lateral ridges which buttress the sides of the valley, and coming to the surface only for a momentary breathing space in the bottom of the ravines between these ridges. There will be twenty-two or twenty-three of these tunnels, the longest of which will be about 1400 feet. On this line of ditch there will be suitable settling reservoirs for the elimination of sand and grit which would otherwise act as a sand blast on the nozzles and wheel buckets and cut them out in a very short time. The ditch will deliver the water to the pipe line, which will be about 1300 feet long and three and one-half feet in diameter steel pipe of sufficient tensile strength to bear the strain of so heavy a column of water. The powerhouse will be situated on a large flat in the botton of the valley well away from the stream, and will be about eighth feet long by forty feet wide and will be constructed with concrete walls and iron trussed roof, and will contain the wheels, generators and transformers. From the power house the water will be conducted back to the stream by an adequate tail race from which it will flow to the rice and taro lands below. The route of the pole line traverses the intervening valleys to Kalihiwaimauka and thence up that valley to the pass overlooking the Wailua watershed, thence across the pafs and back to Kilohana and through the gap to Lawai and thence across the McBryde lands to Hanape. The McBryde Sugar Company will be the main purchasers of the power for the purpose of pumping, and as a cheap substitute for coal, but there is far more power available in Wainiha than McBryde can ever use, which will ultimately be for sale at reasonable rates should there be a demand for it, at any rate in the mean time some 200 horsepower will come to Lihue in return for right of way granted to the Electric Power Company. This will doubtless be rendered available for public and general use in the various ways in which electric power is used.

TRANSPORTATION.

WILMINGTON, CAL.—The Pacific Electric Railway Company has resumed the work on its San Pedro extension.

PORTLAND, OR.—The Portland Consolidated Street Railway Company announces that it will extend its interurban system to Forest Grove, Or.

FOREST GROVE, OR.—The Southern Pacific Company is installing a suburban street car system hereabouts which is to be operated by gasoline motor cars.

OCEANSIDE, CAL.—John McCafferty, of Pasadena, is investigating a project contemplating the building of an electric railway from San Bernardino to Oceanside.

SAN DIEGO, CAL.—The San Diego Electric Railway Company has purchased a franchise for $1100 permitting the extension of its roads from State and D streets to Old Town.

VISALIA, CAL.—The Mt. Whitney Power Company has given a contract for the building of an electric rai road between Exeter and Lemon Cove, the same to be finished about April 15th.

REDLANDS, CAL.—A report is current that the Huntington interests propose to extend their Los Angeles interurban system to Redlands and that parties are now in the field securing rights of way.

SANTA ROSA, CAL.—President John A. McNear is authority for the statement that a branch of the Petaluma and Santa Rosa Railway will be built immediately between Petaluma and Point Pedro.

CHICO, CAL.—Mayor A. F. Jones, of Oroville, and who is chief attorney for the Diamond Match Company, has petitioned the Board of Supervisors for a franchise for a railway to extend from this city to Oroville.

PORTLAND, OR.—The Oregon Water Power and Railway Company has secured a right of way from Cedarville two miles west of Gresham to the Columbia River opposite Washougal, by way of Fairview and Troutdale.

CHEHALIS, WASH.—J. M. Hartfield, K. Bezemer and Robert Haskell are to incorporate a company for the purpose of building an electric road and transmission plant, the former to cost $450,000 and the latter $150,000.

SAN JOSE, CAL.—The San Jose and Los Gatos Interurban Railway Company, and presumably allied corporations, are securing many franchises in order to complete its system hereabouts and towards San Francisco.

VACAVILLE, CAL.—W. H. Goucher, representing the promoters of an electric line which it is proposed to build from some point on the Bay of San Francisco to Vacaville, Winters and Woodland, has been securing rights of way hereabouts.

STOCKTON, CAL.—The system of the Stockton Street Railway Company is to be changed in the spring to a broad gauge road. The plans are in the hands of Henry H. Lynch of San Francisco, and they contemplate an expenditure of $300,000.

WALLA WALLA, WASH.—Frank Smith has acquired an interest in the Walla Walla Street Railway Company, being promoted by Edwin S. Isaacs, and states that a local and suburban system will be built and in operation before the end of the year.

SAN FRANCISCO, CAL.—The Board of Supervisors has granted permission to the United Railroads to operate an electric railroad over the old California Street steam dummy line from Parker Avenue to the Cliff House, and the alteration is already under way.

SAN JOSE, CAL.—Robert N. Frick, of San Francisco, has petitioned the Board of Supervisors for a franchise for a single track standard gauge electric railroad to run from Milpetas to the northern boundry of the county, and to extend for a period of fifty years.

LOS ANGELES, CAL.—The Los Angeles Pacific Railway Company is surveying a line to connect Sawtelle with the Soldiers Home by way of the canyon. The Pacific Electric Railway Company is to build an electric railway connecting Huntington Beach with Newport Beach.

RED BLUFF, CAL.—Ed. B. Walbridge, owner and proprietor of of the well known hotel at Tuscan Springs, Tehama County, has applied for a franchise for an electric road nine miles in length which he proposes to build from this city to Tuscan Springs during the present summer.

SPOKANE, WASH.—J. P. Graves, president of the Spokane Traction Company, states that it has secured riparian rights at Nine Mile Bridge and there will install a power plant to cost between $600,000 and $700,000 for the development of 12,000 horsepower for the operation of the road.

SAN FRANCISCO, CAL.—A special meeting of the Petaluma and Santa Rosa Electric Railway Company has been called for April 15th for the purpose of creating a bonded indebtedness of $250,000 in addition to the bonded indebtedness heretofore created—this money to be used in contemplated extensions.

FALLON, NEV.—A bill has been introduced in the State Legislature granting a right of way to R. T. and W. J. Douglas and W. W. Williams for an electric railroad to run from Fallon to Hazen. It is stated that the road will cost $212,000, and is to be built by a corporation to be known as the Nevada Power and Transportation Company.

VANCOUVER, B. C.—The British Columbia Electric Railway Company has taken over the business and trackage of the branch of the Canadian Pacific Railway known as the Vancouver and Lulu Island Railway extending from this city to Steveston. Hereafter electric locomotives will do all the shunting of freight cars and trains south of False Creek.

NEW WESTMINISTER, B. C.—An electric railway from this city to Chilliwack, by the Chilliwack Light and Power Company, of which J. B. Morgan is general manager with the offices at Chilliwack. The estimated cost of the road is $1500 per mile and the power plant and transmission lines for its operation are estimated to cost $125,000. It is planned to commence construction at once.

PORTLAND, OR.—The Portland, Sandy and Mt. Hood Railway Company has been incorporated by Senator Smith, Napoleon Davis, Guy D. Willis, Al Stone, Geo. L. Story and A. W. Lambert for the purpose of building an electric road, first to Fairview and Troutdale and later to the base of Mt. Hood. Power for the operation of the road is to be developed on the Sandy River near Troutdale.

STOCKTON, CAL.—A report is current that one of the immediate plans of the Huntington Syndicate includes an electric railroad between Stockton and Fresno. The system in both Stockton and Fresno has been in the hands of the Huntington people for some time, and franchises for power lines have already been secured through the San Joaquin Valley from Stockton south.

VANCOUVER, B. C.—Material is arriving and work will be commenced in the near future by the British Columbia Electric Railway Company in converting the steam line of the Lulu Island Railroad to an electric line. The company has obtained a twenty-five year lease on the road, which is seventeen miles long, and will establish an hourly service to Vancouver for freight and passengers.

SANTA BARBARA, CAL.—A new corporation organized under the laws of New Jersey and known as the Interurban Railway Company is to equip and operate an electric railway to run east from State Street in Santa Barbara, Cal.; thence to Summerland, Carpenteria, Ventura and eventually to reach Los Angeles. The capital is $250,000. John B. Miller, F. E. Miller and A. L. Selig are the incorporators.

EUREKA, CAL.—The Humboldt Transit Company has been granted a franchise for an electric road to extend from this city to Arcata. J. E. Green and others have applied to the Board of Supervisors for a franchise for an electric road to be built and operated over certain county roads and a similar franchise covering specified streets in the city of Eureka will be sold during the session of the council to be held on March 14th.

CITY OF MEXICO, MEX.—Wm. McKenzie, of Toronto, Canada, representing capitalists of that city, has arranged to purchase the Mackin & Dillon concessions for an electric car line in Monterey and the Empresa system of mule cars and is now negotiating with Congressman Slayden, of New York, to buy the Slayden system of mule cars, with a view of converting the two systems into an electric line under the terms of the Mackin & Dillon concession.

SAN FRANCISCO, CAL.—The local press reports that the electrical engineer of the Southern Pacific Company has rendered a report discussing the feasibility of changing the local steam lines of the company operating in Oakland, Berkeley and Alameda to electric traction, and is quoted at placing the cost for power on a steam road per train mile at 14.5 cents and that on an electric road at 10.3 cents, as a difference of 4.2 cents. Cost of wages per train mile on a steam road is placed at 12 cents and that on an electric road at 6.7 cents. He than figures that the cost of supplies, maintenance, train crew and power per train-mile on a steam road is 34 cents, as against 21.2 cents on an electric road.

LOS ANGELES, CAL.—Owing to the greatly increased traffic on the interurban railway system of the Los Angeles-Pacific Railroad Company, the officers of the company have decided to increase the capacity of their central power house at Vineyard and to install an additional substation in Los Angeles. The new electrical equipment has recently been contracted for with the Crocker-Wheeler Company, through its Pacific Coast managers, the Abner Doble Company, of San Francisco. The contract comprises one 1200-kilowatt, three-phase, fifty-cycle, 2300-volt, engine-type generator with a speed of 125 revolutions per minute; one 300-kilowatt motor-generater set; one 400-kilowatt motor-generator set; three 400-kilowatt transformers; three 160-kilowatt transformers; three 120-kilowatt transformers and a sixty-kilowatt engine-type exciter. The 1200-kilowatt alternator will be of the Crocker-Wheeler Company's new revolving field type, similar in construction to the three 4000-kilowatt alternators recently ordered by the California Gas and Electric Corporation. The Los Angeles generator will be driven by a 2000 horsepower compound condensing McIntosh & Seymour engine. The motor-generator

sets will consist of 2300-volt synchronous motors driving 600-volt direct-current railway generators. The transformers will be built for 15,000 volts on the primary and 2300 volts on the secondary, and will be of the new water-cooled and oil-insulated type recently brought out by the Crocker-Wheeler Company.

The interurban railway system of the Los Angeles-Pacific Railroad Company is one of the most extensive in the country, embracing as it does nearly 200 miles of up-to-date lines. The company owes its growth largely to the energetic and untiring work of the president and manager, E. P. Clark, who was one of the pioneer railway men of southern California and who has seen his system develop from a very small beginning to its present commanding position in the traction field. The system extends from Los Angeles in a fan shape to Santa Monica, Ocean Park, Playa del Rey, Hermosa, Manhatten Beach and Redondo on the ocean, and passes through the intermediate towns of Hollywood, Colegrove, Sawtelle, Sherman and Palms. In other words, the lines cover thoroughly the territory lying south of the Santa Monica Mountains and between Los Angeles and the ocean. Most of the lines have been double tracked and are constructed in conformity with the best steam railroad practice. About a year ago a new central steam plant was installed at Vineyard, about five miles west of Los Angeles, and from this station transmission lines at 15,000 volts carry the power to several substations located at intervals over the system. It is to increase the capacity of this central station and to supply additional power for the operation of the lines in Los Angeles that makes necessary the additional machinery mentioned.

ILLUMINATION.

SUISUN, CAL.—Leonard Prior has been granted a local electric lighting franchise.

STOCKTON, CAL.—The Stockton Gas and Electric Cempany has advanced its electric rate from 5 cents to 7 cents per kilowatt hour.

SOUTH BEND, WASH.—J. M. Eitner and A. P. Leonard propose to install an electric light plant here, which will be the second in South Bend.

SPARKS, NEV.—C. E. Clough and others are organizing a company for the purpose of supplying water and electric light and power hereabouts.

EUREKA, CAL.—The Cheney, Kelly & Reid Company are installing a 200 light dynamo in the new brewery of the Eureka Brewing Company.

IONE, CAL.—The American River Electric Company is building a substation at this place for the local distribution of Electric light and power.

CITY OF MEXICO, MEX.—On February, 5th, the engine and dynamo rooms of the plant of the Mexican Electric Works was damaged by fire to the extent of $350,000.

BRIGHAM CITY, UTAH,—A. L. White and V. F. Davis have been granted a franchise for the erection of an electric light pole line along the country road from Brigham City to Logan.

ANAHEIM, CAL.—Some of the City Trustees are in favor of voting municipal bonds in the amount of from $10,000 to $15,000 for the purpose of enlarging the city electric and water plants.

REARDAN, WASH.—The Reardan Light and Power Company, lately organized by J. M. McDowell, Frank Bralley, John Field and others, will probably have its electric lighting plant in operation by March, 1st.

ABERDEEN, WASH.—J. D. Crary, manager of the Gray's Harbor Electric Light and Power Company, proposes to expend about $75,000 during the present summer in improvements through the local lighting plant.

SACRAMENTO, CAL.—Many repairs to the State Capitol are contemplated, and among the improvements proposed are the installiation of the new elevators, incandescant electric wiring and electric gas lighting and telephone systems.

PRAIRIE CITY, OR.—F. F. Wright, Dr. Carlton Faull and Alfred Curre, of Baker City, have taken an option for the purchase of the Prairie City Electric Light Plant and if the deal is consumated they will spend $25,000 in its improvement.

KELSEYVILLE, CAL.—The Kelseyville Natural Gas, Electric Light and Power Company has been incorporated by J. V. Davis, L. H. Boggs, J. B. Laughlin and others for the purpose of developing natural gas for the operation of an electric lighting and gas heating plant.

EUREKA, CAL.—The H. B. Switzer Company, Inc., which has been incorporated by H. B. Switzer, C. C. Mitchell, E. J. Bosburg and others with a capital stock of $25,000 for the purpose of engaging in the lumber milling business, is empowered with the right to generate and sell electricity.

CITY OF MEXICO, MEX.—The municipal authorities of Temascaltepec have authorized the Governor of the State of Mexico to negotiate and signa contract with the representative of Senores Francisco Seguaro and Hermano, of Mexico City, for the installation of an electric light plant in that town.

SANTA FE, N. M.—The Las Cruces Electric Light and Ice Company has incorporated by Ben L. Berkley, Joseph Wilkinson, of El Paso, Theodore Rouault, Henry D. Bowman, *et al.*, of Las Cruces. Object to construct and operate a water system in Las Cruces, electric light and power plant and build ice plants. Place of business Las Cruces.

GOLDFIELD, NEV.—The electric lighting station at this place consists of a fifty kilowatt, 2300-volt, three-phase Stanley generator driven by a Corliss engine. Oil fuel is used, costing $4.50 per barrel with the prospect of the cost being soon raised to $6.50 per barrel. Undoubtedly power will be taken from the Nevada Power, Mining and Milling Company transmission line as soon as its system is completed.

LOS ANGELES, CAL.—The Los Angeles Business Mens Electric Company has been organized by local merchants and it is expected, will shortly be incorporated with a capital stock of $500,000 for the purpose of building and operating an independent Electric Lighting Company. Prominent among those who have subscribed to the stock of the new company are: Major J. H. Norton, J. M. Snyder, Avory McCarthy, N. Bonfilio and C. W. Fleming.

ARCATA, CAL.—Brousse Brizard, who purchased the electric plant at this place, is to transfer the property to the recently incorpoeated Arcata Light and Power Company, the principal owners of which are Peter M. Tracey, V. Burry, E. E. Skinner, L. J. Archer and B. Brizard. The capital stock is $50,000 of which $19,100 has been subscribed, and power for the operation of the plant will undoubtedly be taken from the transmission circuits of the North Mountain Power Company.

SANTA BARBARA, CAL.—The Merchant's Mutal Electric Light and Power Company has been incorporated by W. H. R. Welden, W. S. Show, C. H. Frink, J. H. Burson, Jno. T. Johnston, J. F. Diehl and J. F. Trenwith, with a capital stock of $250,000, of which $26,400 has been subscribed. This company has been organized under the direction of the Commercial Club and the Chamber of Commerce for the purpose of furnishing light and power to the merchants of the city at a rate cheaper than that now charged by the Edison Electric Company, of Los Angeles.

GAS.

OCEAN PARK, CAL.—A. C. Barke is endeavoring to establish a competitive gas plant at this place.

ORANGE, CAL.—The Orange Gas Company began the regular mauufacture of gas on January 17th.

EVERETT, WASH.—The Everett Gas Company is about to expend $15,000 in improvements to its gas plant.

SANTA ANA, CAL.—Natural gas has been found by Superindent Lancaster, of the Newport Beach Company, on one of the salt marshes of Newport Bay.

LOS ANGELES, CAL.—The high pressure gas main now being operated by the Los Angeles Gas and Electric Company is to be extended from Pasadena to Alhambra.

VALLEJO, CAL.—The price of gas has been voluntarily reduced by the Vallejo Gas and Electric Company from $2.50 to $2.00 per thousand provided bills are paid before the 15th of the month of presentation.

SPOKANE, WASH.—The Union Gas Company occupying the franchise granted to Roger Williams last July has let a contract for the building of a gas plant with a daily capacity of 500,000 feet and to cost about $250,000, to a Cincinnati firm.

LOS ANGELES, CAL.—The Independent Gas Company announces that all obstructions, legal and otherwise, have been removed and that it now proposes to begin the systematic and extensive laying of gas mains to all parts of the city.

COVINA, CAL.—Two carloads of machinery which arrived for the Covina Valley Gas Company in January have been installed by S. M. Walker of the Pioneer Boiler and Machine Works of Los Angeles. The plant will be in operation shortly.

PALO ALTO, CAL.—The Palo Alto Gas Company recently incorporated by D. O. Druffel, of Santa Clara, has begun laying gas mains for the local distribution of gas to be bought from the Redwood City Plant of the United Gas and Electric Company, of San Jose.

POMONA, CAL.—The State Supreme Court has handed down its decision in the cases of Paul J. Denninger vs. the city of Pomona, and of I. C. Carter. This decision is to the effect that cities of the fifth class have the constitutional right to fix the price of gas when it is furnished to citizens by a corporation which has a monopoly.

SAN FRANCISCO, CAL.—The San Francisco Gas and Coke Company has obtained a permit to lay gas mains in the district bounded by Bay, Sansome, Market and Powell streets. The gas pipe to be laid ranges in diameter from six to twenty-four inches and the first shipment of the $250,000 order for it is on the way from Chicago.

SAN FRANCISCO, CAL.—Wm. Evans formally a coal passer in the employ of the Independent Gas and Power Company, and who lost his right arm and three fingers of his left hand in an accident while in the company's employ last June, has compromised for $4500, the amount which he brought for damages amounting to $75,000.

HOAQUIAM, WASH.—C. E. Burrows has been granted a franchise for a gas and heating plant which is part of the proposed enterprise to be built in Aberdeen and other towns of the harbor to supply gas for light, heating, etc. R. J. Hilts states that a company will be incorporated with $50,000 to be called the Hoquiam Heating and Light Company.

ANAHEIM, CAL.—The Anaheim Gas Company has been incorporated by L. E. Miller, B. V. Beebe, T. S. Grimshaw, I. M. Beebe and M. K. Miller with a capital stock of $75,000 of which $17,000 has been subscribed. Its principal place of business is Anaheim and it is empowered to manufacture gas, to hold and sell water rights and to engage in the electrical or other business.

SAN FRANCISCO, CAL.—S. F. Alden & Co., representing the Davis & Farnum Manufacturing Co., of Waltham, Mass., has sold three steel gas holders with a capacity of 1,400,000 cubic feet to the California Gas and Electric Corporation. The shipment will consist of about fifty carloads of material, the contract price for which approximates $125,000. These holders are to be erected at the gas engine power station of the corporation in San Francisco.

FRESNO, CAL.—Experiments are being conducted at the gas works of the Fresno Gas and Electric Light Company upon a 135 horsepower Snow gas engine with the view of determining its behavior and efficiency when consuming the 630 British thermal units produced at this plant. This gas is identical with that to be generated by the new gas plant to be installed near San Francisco by the California Gas and Electric Corporation for the operation of the three 4000-kilowatt gas engine generator units there to be erected.

KELSEYVILLE, CAL.—The Kelseville Natural Gas, Electric Light and Power Company has been incorporated by J. D. Davis, L. H. Boggs, L. Henderson, J. B. Laughlin and W. M. Nobles, who have bought the property known as the gas hill, and will develop it for the uses named in its title—first for the generation of power for electric lighting in all parts of the country, and for electric roads and propulsion of machinery in manufacturing enterprises. Already applications have been received for power for the operating of an ice plant and a laundry.

SAN FRANCISCO, CAL.—The San Mateo Power Company has been incorporated by Henry Bostwick and other representatives of the California Gas and Electric Corporation with a capital stock of $1,000,000. This company is to operate the 15,000 horsepower gas engine driven electric plant of the corporation named. The first of the three engines is to be shipped on April 1st, the second on June 1st, and the third on August 1st, of this year, so that the plant may be in operation by January 1st, next, in accordance with the contract existing with the United Railroads.

VANCOUVER, B. C.—The Vancouver Gas Company, limited, recently taken over by the British Columbia Electric Railway Company is receiving tenders for a 150,000-foot gas holder. The entire works are being remodeled, fourteen miles of main are being laid and the output will be increased considerably. The company has established a cooking school to better acquaint the residents of the city with the convenience of gas and is preparing to establish a model kitchen. It is also intended to establish a cooking school in a tent on the bay shore during the summer. Decided progress is shown under the new management in securing business.

TELEPHONE AND TELEGRAPH.

TENINO, WASH.—J. F. McClelland has been granted a county telephone franchise.

POMONA, CAL.—The City Trustees are considering the advisability of installing a fire alarm system.

YERRINGTON, NEV.—The Government will build telephone lines along the Truckee-Carson irrigation canal.

JULIAN, CAL.—Dr. Hunt is circulating a subscription list for the extension of the Julian Telephone system to Cuyamaca.

SANTA BARBARA, CAL.—E. F. R. Vail has applied for a franchise permitting the erection of telephone and telegraph lines throughout the county.

SONOMA, CAL.—Six farmers telephone lines, all centering in Sonoma, are now being installed under the franchise recently granted to L. Breitenbach.

BAKERSFIELD, CAL.—Sealed proposals will be received until March, 6th, upon specifications that have been issued for a fire alarm telegraph system.

SANTA ROSA, CAL.—The Healdsburg and Alexander Valley Telephone Company has been incorporated by C. W. Mathews, W. F. Young, L. J. Hall and others.

BREMERTON, WASH.—The Peninsula Telephone Company is extending its lines to Poulsbo, Manchester, Olalla and other parts of this county and to Big Harbor in Pierce County.

HONOLULU, T. H.—The Standard Telephone Company has applied for a franchise to establish an automatic telephone system in and about Honolulu using underground conduits.

CRESCENT CITY, CAL.—Willis Baine is purchasing poles for a Farmers Telephone Company that is installing a telephone system extending from this city to Smith River Valley.

SANTA ROSA, CAL.—The Dry Creek and Healdsburg Telephone Company has been incorporated by Geo. Thayer, A. Galloway, C. N. Blazer and others with a capital stock of $100,000.

MERCED, CAL.—H. G. Turner, vice-president, of the Grange Warehouse Company, of Modesto, has applied for a franchise for erecting telephone poles between Modesto and Madera.

MILL VALLEY, CAL.—The Mill Valley and Mt. Tamalpias Scenic Railway Company has applied for a franchise for the erection of telephone and telegraph poles throughout Mill Valley.

PASO ROBLES, CAL.—The Paso Robles and Shandon Telephone Company is about to be incorporated for the purpose of building and operating a telephone line between Paso Robles and Shandon.

NORTH YAKIMA, WASH.—The Selah Telephone Company, of which E. E. Hanna is president and F. L. Carardoneau is secretary and treasurer is to build a telephone line from this city through Salah Valley.

OAKLAND, CAL.—An ordinance is to be introduced before the City Council which will have as its principal features the giving of all corporations using electricity three years in which to put their wires underground.

SANDY, OR.—A. Meineg, representing a number of farmers of this vicinity, states that a joint stock company is to be organized for the purpose of building a farmers telephone system with a through line to Portland.

SAN FRANCISCO, CAL.—The Direct Line Telephone Company has applied to the Board of Supervisors for permission "to run wires across and under streets." The application has been referred to the City Attorney.

SPOKANE, WASH.—Chas. Sumner has applied for an independent telephone franchise, offering $90,000 therefor, and agreeing to expend $600,000 within three years in equipping the proposed plant with an automatic system.

WAITSBURG, WASH.—The Waitsburg Rural Telephone Company has been incorporated by J. W. Morgan, A. W. Phillips, Gustav Vollmer, W. B. Brook, E. M. Denton, Frank Jonas and W. E. Price with a capital stock of $10,000.

BODIE, CAL.—The Walker River Electrical Company has been incorporated by Arthur Cohn, Wm. Reading, Chas. Day and others for the purpose of building and operating a telephone line between Carson, Wellington and Yerrington.

LOS ANGELES, CAL.—The Santa Clara Valley Home Telephone Company has been incorporated by C. F. Guthridge, C. L. Zahn, D. F. Boice, C. P. Platt and A. Wright, with a capital stock of $75,000 of which $10,000 has been subscribed.

HELENA, MONT.—The Wiboux Investment Company has been incorporated by J. R. Cornell, Frank Cannon, J. G. Stewart and W. A. Orgain, with a capital stock of $5,000, for the purpose of building a telephone line from Wilboux to Ekalaka.

OREGON CITY, OR.—The New Era Telephone Company is to be incorporated by Elmer Vetto, Barry Frederich, G. H. Brown and D. McArthur for the purpose of building a telephone line to radiate from New Era to Oregon City and elsewhere.

LOS ANGELES, CAL.—A meeting of the stock holders of the Oxnard Home Telephone Company, will be held on April, 11th, at the offices of the company 305 Currier Building, Los Angeles, to consider the creation of a $50,000, 5 per cent., bonded indebtedness.

SANTA MONICA, CAL.—The stockholders of the Home Telephone Company have authorized an issue of $150,000 in 5 per cent. bonds, the proceeds from which will be used in completeing the system now being installed in Santa Monica and Ocean Park.

SALEM, OR.—W. H. Dancy, local manager for the Pacific States Telephone and Telegraph Company states that the company's system in Salem is to be entirely rebuilt and that contracts for the new service dating from May 1st, are now being signed.

CITY OF MEXICO, MEX.—The Mexican Telephone Company of which T. F. Maguire is general manager, states that plans and specifications are now prepared and the company is ready to receive bids for the excavation, the furnishing and laying of ducts and all other matters pertaining to the laying of the underground system.

LOS ANGELES, CAL.—San Jacinto and Hemet Home Telephone Company has purchased complete Strowberg-Carlson equipment for its new exchange through the agency of B. F. Kierulff, Jr., & Co., of this city. The Monrovia Exchange has also adopted Strowberg instruments for future equipment.

SALT LAKE, UTAH.—John Angus, of Jensen, has been awarded the contract for the construction of a telephone line for the Uintah Railway Company, from Dragon to White River. It is the intention of the company to extend the line to Vernal and Fort Duchesne at an early date.

BELLINGHAM, WASH.—Plans are being perfected by Jno. C. Gillis, P. D. Harkness, Dr. O. E. Beebe, L. C. Durr, and J. Bailey for the organization of an Independent Co-operative Telephone Company which will have headquarters in Everson with lines extending to Nooksack, Clearbrook, Goshen, Vanburen, Forrest Grove and elsewhere.

SAN BERNARDINO, CAL.—The Southwestern Home Telephone Company, recently incorporated by K. C. Wells, A. Gregory, C. H. Biglow and others, is to build telephone lines from Redlands, Beaumont, Banning, San Jacinto and Hemet and thence along the line of the Southern Pacific Company to Yuma, Ariz. Construction is already in progress.

REDLANDS, CAL.—The Sunset Telephone and Telegraph Company will commence active operations at once connecting southern California with Arizona and New Mexico. The line will be run through the Imperial Valley, taking the towns en-route and connect at Yuma with the Yuma line and those running into New Mexico. Actual work will commence in March.

RENO, NEV.—The Southern Pacific Company has begun the first work of installing an electric light and power system along its road between Ogden and San Francisco. It is the aim to use the power for switch lights, station lights and other purposes from one end of the system to the other, the power to be developed entirely by this company. The first plant is near Carlin.

BROWNSVILLE, OR.—The Pacific States Telephone and Telegraph Company, through D. H. Drewsey, has submitted a proposition to the Pioneer Mutual Telephone Company, of this city, proposing to furnish each independent telephone with an American Bell transmitter and receiver for the sum of $2.00 per year rent for each subscriber, and to place on the free list the towns of Brownsville, Halsey, Plainview, Shedd, Peoria, Corvallis and Philomath.

WATER WORKS.

SAN JUAN, CAL.—The Board of Health has recommended that the town trustees install a water system if possible.

SEBASTOPOL, CAL.—The City Trustees have investigated the cost of installing a municipal water system and find that it can be built for $35,000.

DUNSMUIR, CAL.—The Shasta Springs Company will begin construction of a new water works for this place early in March under the direction of James Stanley.

COLVILLE, WASH.—The City Council has authorized the sale of $12,000 in twenty-years not to exceed 6 per cent. bonds, for the construction of a water system.

BLAINE, WASH.—The report is credited that the Monarch Lumber Company will install a water system in this city provided it can secure a satisfactory franchise.

BENICIA, CAL.—The Benicia Water Company has been incorporated by John E. Miles, Alexander Hamilton, Chas. N. Brier and others with a capital stock of $500,000.

BISBEE, ARIZ.—The Bailey Water System, having been sold to the Bisbee-Naco Water Company, is to be improved by the construction of a new pumping station.

LOS ANGELES, CAL.—Dr. D. W. Edwards, president of the Bimini, states that his company is to erect a new building for Turkish, Russian and other hot medicinal baths at the Bimini Soda Hot Springs.

VALLEJO, CAL.—The question of bonding the city in the sum of $90,000 to procure a new right of way for the municipal water system and to enlarge and improve its pipe lines will be voted upon February 27th.

VICTORIA, B. C.—The services of Arthur L. Adams, a water works engineer, have been engaged by the mayor to conduct an investigation into the requirements of this city for the improvement of its water works.

POINT RICHMOND, CAL.—The West San Pablo Land and Water Company of which W. B. Hellings, of San Francisco, is manager is preparing to lay water mains and laterals throughout the Santa Fe, Richmond and Oldtown tracks.

VENTURA, CAL.—A special election has been called for April 22d for voting on an issue of $100,000 in bonds for the establishment of a municipal water plant, of $25,000 for an electric lighting plant and of $10,000 for the sewer system.

VERNON, B. C.—A certificate of incorporation has been granted to the Similkaneen Water Works Company, (Ltd.), to construct and operate a water works system for the unincorporated locality known as Hadley, together with its surrounding country.

OAKLAND, CAL.—An ordinance has been passed calling for a bond election to be held on March 11th to pass upon the question of bonding the city to the amount of $5,700,000 for the purpose of purchasing the water system proposed by the Bay City Water Company.

CHICO, CAL.—The Chico Water Company is to make a number of important improvements this spring, principal among which will be the erection of a steel tower for the support of a 100,000 gallon tank, the installation of an electric motor and centrifugal pump at its new well on Fifth and Olive streets and the laying of new twelve inch mains to Barber and parts of Chapman town.

SAUSALITO, CAL.—A special election held on February 21st, for the purpose of determining whether the town hall incur a bonded indebtedness of $100,000 for the acquisition of a new water system failed to carry. The North Side Water Company has been installed by John Richards, of San Anselmo, J. E. Manney, Geo. Bromwell and others, with a capital stock of $50,000, for the purpose of installing and operating a water plant.

MONROVIA, CAL.—A mass meeting of citizens has been held to consider the advisability of bonding the city in the sum of $50,000 for building a water works, and as a result the Board of Trustees has passed an election bond ordinance to print providing for municipal improvements to the extent of $45,000 of which $6500 is to be used for the purchase of an air compressor to be installed at Chapman wells, $4000 for an alternating current electric motor and a single acting thirteen by twelve triplex pump and $9500 for iron and cement pipe.

SPARKS, NEV.—The Washoe Deep Well Company has been incorporated by Humphrey Bros., the Evans estate, C. E. Clough and others with a capital stock of $100,000; principal place of business at Reno. The company proposes to install a water works at Sparks for which most of the pipe has already been ordered. At the outset steam pumping will be resorted to, but the finished installation will consist of two forty horsepower motors driving centrifugal pumps, and storage is to be obtained through the erection of a 100,000 gallon redwood tank at an elevation of ninety feet.

OIL.

SAN DIEGO, CAL.—The Western Metal Supply Company representing the Union Oil Company proposed to lay a pipe line into the bay through which tank steamers may discharge their cargo.

SALINAS, CAL—The Coalinga Oil and Transportation Company has applied for a franchise to lay an oil pipe line in certain streets of Salinas for the purpose of filling three oil tanks having a combined capacity of 30,000 gallons.

CARLSBAD, N. M.—Important developments in the oil fields of Carlsbad are promised by the recently incorporated Canton, Penasco, Artesian, Otero, Hunda and Mountain Oil Companies as well as by Mount Bros., Beck, Hudson & Co., the Snyder Syndicate, the Teegarden Syndicate and the Carlsbad Consolidated Oil Company who are importing oil drilling outfits and preparing for immediate developments.

SAN FRANCISCO, CAL.—A current news item reports that it is now said that the Standard Oil Company anticipates having its line in shape to pump oil from Kern River to Point Richmond soon after March 1st, when the additional pumping stations, on which it has been working for nearly a year, and which have been talked of for eighteen months, will be completed, and it is fondly hoped that with the improvements it will be possible to pump for a distance of nearly 300 miles the thick, heavy crude oil of Kern River, which flows through the pipes about as readily as molasses in cold weather, and which has already caused the Standard's officials more worry and expense, perhaps, than anything else on the coast. Just when the actual pumping may begin is all a matter of conjecture.

SAN FRANCISCO, CAL.—The production of crude oil in California for 1903 and 1904 as reported by the California Petroleum Miners' Association, is as follows.

District	1903. Barrels.	1904. Barrels.
Fullerton	250,000	876,000
Puente	100,000	204,000
Whittier	50,000	780,000
Los Angeles	900,000	1,080,000
Newhall and Ventura	900,000	540,000
Summerland	100,000	80,000
Santa Maria	1,000,000	750,000
Kern River	15,750,000	17,500,000
Sunset and Midway	250,000	376,000
McKittrick	1,700,000	1,650,000
Coalinga	2,600,000	4,544,160
Sargents	11,000	42,700
Halfmoon Bay	1,000	1,000
Total	23,602,000	28,423,860

This production places California far ahead of any other state in the union, and far ahead of any other country except Russia.

MISCELLANEOUS.

TUSCARORA, NEV.—The hydro-electric power plant of the Dexter-Tuscarora Mines Company burned on February 21st. Loss approximately $5000.

DESERVED ENGINEERING RECOGNITION.

IN awarding grand prizes the International Committee of the Louisiana Purchase Exposition has recognized the engineering ability of the designers of the apparatus exhibited by the General Electric Company, as follows:

To Elihu Thomson, for various applications of electricity; also to C. P. Steinmetz, for electric lighting, and to F. J. Sprague for application of electricity to transportation. It has also awarded gold medals to C. G. Curtis "the originator of a successful American multi-stage steam turbine;" to W. L. R. Emmett, "desiguer of the vertical type of curtis steam turbine and generator;" and to W. B. Potter for applications of electricity to transportation. Sliver medals were awarded to W. S. Moody for transformers; to E. M. Hewlett for distribution of energy, switchboards, etc., to H. F. T. Erbenj for apparatus for generating electricity; to H. G. Reist for apparatus for generating electricity; to L. T. Robinson for scientific apparatus, measuring apparatus aud laboratory and standard instruments, and to F. P. Cox for measuring instruments, indicating, recording and intergrating.